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California Fish and Game, 55(4) : 260-264, 1969.

DISTRIBUTION OF CALIFORNIA ANGLING EFFORT IN 1968[1]

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A postcard survey of licensed anglers was conducted to determine the distribution of 1968 sport fishing effort in (i) ocean waters, (ii) fresh waters (including the Salton Sea) and (iii) the waters of San Francisco Bay and the Sacramento-San Joaquin Delta. Estimated percentages of total angler-days spent in the above water categories are 25.2, 64.2, and 10.6, respectively. Proportions of licensees fishing in each type of water are estimated at 0.436, 0.747, and 0.167, and the proportions of anglers fishing exclusively in the particular water category are 0.111, 0.382, and 0.017. An estimated 10.9% of all licensees did not fish. Standard errors of the estimates were calculated. Results of this survey differ significantly from comparable estimates of 1961 effort distribution. A positive response bias of about 250% in the survey estimate of total angler-days spent on party boats and barges is indicated by comparing that statistic with compulsory logbook data.

INTRODUCTION

This is the third in a series of reports on postcard surveys designed to estimate angling effort distribution among three major California water types. The first surveyed 1951 sport fishing (Clark, 1953), the second covered 1961 (Abramson, 1963), and this report presents the results of a survey of 1968 anglers. Estimated values are the proportion of angler-days spent in ocean, fresh, and San Francisco Bay and Sacramento-San Joaquin Delta waters; proportion and number of licensees who fished in each type of water, and of anglers fishing exclusively in one of the water types; and proportion and number of those who did not fish.

STATISTICAL DESIGN AND OPERATING PROCEDURES

The survey employed the identical statistical design used in 1961 (Abramson, 1963). We believe the methods produce estimates which are relatively free from both response bias and nonresponse bias. The number of angling days spent in various types of water are statistics of considerable interest to fisheries management; however, estimates of such effort are liable to large positive response biases. To assess the magnitude of these biases, the survey questionnaire included a request for the number of days the licensee spent on party boats, charter boats, or barges in ocean or San Francisco Bay waters. Total days computed from responses to this question were compared with totals compiled from compulsory logbook records maintained by the operators of such vessels.

Execution of the 1968 survey was essentially the same as for the 1961 survey. A new method of licensing California anglers required an

[1] Accepted for publication May 1969.

additional assumption in the method of sample selection. Under the renewable sport fishing license system initiated by the Department of Fish and Game in 1967, purchase of an annual stamp validates a permanent license form. On each folder of annual resident stamps, the name and address of the first licensee are recorded. We must assume that the first licensee represents a random selection from the 25 persons licensed from the same folder.

Four independent systematic samples of names were drawn for mailing, each with a sampling fraction of 1/64, resulting in an effective sampling fraction of 1/400. About 1,884,800 annual resident licensees constituted the sampled population; 33,000 nonresident license holders were excluded because no record is kept of the names. Slightly more than 24,400 additional annual resident licenses were sold but were not available when the samples were drawn.

Maintenance of the master address file, sample identification, and postcard preparation followed the procedure established for the 1961 survey. Three mailings, an original plus two follow-up requests, were scheduled at 3-week intervals beginning February 14, 1969.

RESULTS

About 4.2% of the questionnaires were returned undelivered because of incorrect or incomplete address and were deleted from the samples. Effective sample sizes were 1,119, 1,139, 1,141, and 1,117. Total response was 68%: 39% to the initial request, 19% to the first follow-up, and 10% to the final reminder (Table 1). The second request elicited replies from 31% of licensees who did not answer the first, and the third mailing prompted 24% response from the remaining nonrespondents.

Of total angler effort, 10.6% was spent in San Francisco Bay-Delta waters, 64.2% in fresh water, and 25.2% in ocean waters (Table 2).

Coefficients of variation (standard error of the estimated proportion divided by that estimate) varied from 0.009 for fresh water to 0.021 for Bay-Delta waters.

The estimated proportions of licensees who fished at least one day during 1968 are 0.167, 0.747, and 0.436 for San Francisco Bay-Delta, fresh, and ocean waters, respectively. Coefficients of variation are less than 0.037. Based on the sale of 1,920,143 annual resident and annual nonresident licenses, the estimated number of anglers fishing at least one day in Bay-Delta waters is 320,663; in fresh water, 1,434,347; and in the ocean, 837,182.

Estimated proportions of licensees fishing exclusively in one type of water are 0.017, 0.382, and 0.111 for water types in the above order, with corresponding coefficients of variation of 0.113, 0.023, and 0.078. This means that approximately 32,642 anglers fished only in Bay-Delta waters, 733,495 in fresh water, and 213,136 in ocean waters.

License holders who did not fish at all during 1968 comprised 10.9%, or 209,296, of all licensees. The coefficient of variation was 0.0623.

TABLE 1

Cumulative Sample Totals from 1968 Angling Effort Survey

Response wave	Sample 1			Sample 2			Sample 3			Sample 1		
	1	2	3	1	2	3	1	2	3	1	2	3
Days angled in:												
San Francisco Bay and Delta	1,228	1,604	1,912	1,003	1,350	1,604	1,152	1,465	1,693	1,181	1,726	1,992
Fresh water	6,751	9,341	10,538	6,924	10,266	11,740	6,746	9,198	10,016	6,107	9,130	10,559
Ocean	2,567	3,612	4,071	2,311	3,125	3,811	2,985	4,071	4,521	2,695	3,831	1,176
Licensees fishing in:												
San Francisco Bay and Delta	83	120	110	81	118	135	79	118	125	72	108	128
Fresh water	362	518	598	356	522	600	363	523	581	333	196	582
Ocean	225	303	316	216	305	353	260	353	387	243	324	383
Licensees fishing only in:												
San Francisco Bay and Delta	5	7	10	11	15	15	4	8	10	5	10	11
Fresh water	161	215	291	161	251	293	117	229	265	138	227	271
Ocean	12	60	71	38	59	73	53	79	91	60	82	101
Licensees not fishing	21	11	58	26	57	76	30	51	73	27	19	63
Number of responses	135	638	719	139	665	778	162	678	775	133	615	769
Sample size		1,119			1,139			1,111			1,117	

TABLE 2

Estimates and Standard Errors

Estimates	S.F. Bay and Delta		Fresh water		Ocean	
	Proportion	S.E.	Proportion	S.E.	Proportion	S.E.
Angling days	0.106	0.00223	0.642	0.00600	0.252	0.00455
Licensees fishing	0.167	0.00610	0.747	0.00994	0.436	0.00858
Licensees fishing exclusively	0.017	0.00192	0.382	0.00863	0.111	0.00864
	Number	S.E.	Number	S.E.	Number	S.E.
Licensees fishing	320,663	11,713	1,434,347	19,086	837,182	16,475
Licensees fishing exclusively	32,642	3,687	733,495	16,571	213,136	16,590
	Proportion	S.E.	Number	S.E.		
Licensees not fishing	0.109	0.00679	209,296	13,038		

DISCUSSION

Both the revision in the licensing system and the increase in license sales from 1961 to 1968 necessitated changes in sample selection. The 1961 sample population included all resident and nonresident licensees; as previously mentioned, nonresident licensees were not sampled in 1968 because mailing information was unavailable. In 1961, 1 of each 250 licensees was sampled. Reflecting the half million license increase, the 1968 sampling ratio, 1 400, produced only slightly smaller samples. The percentage of response was nearly identical in both surveys.

The 1961 estimates of numbers of anglers were based on the sale of 1,365,410 resident and both annual and 10-day nonresident licenses, whereas about 23,000 10-day nonresident licenses were not included in 1968 estimates. As before, these estimates do not include effort for persons fishing in ocean waters from public piers and anglers younger than 16, who are not required to purchase licenses, or for the 203,047 holders of 1968 3-day Pacific Ocean licenses.

Substantial response bias was indicated in the estimate of angler-days spent on charter or party boats. This estimate of 2.4 million days, computed from survey reply data, proved about 250% greater than the 936,000 days totaled from logbook records. We assume such bias also exists in other estimates of angler-days; however, because we cannot show that the bias with respect to other water types is identical, we do not present those statistics.

Comparison of individual estimates between the two surveys shows an increase in numbers of anglers in all cases except those fishing exclusively in San Francisco Bay and Sacramento-San Joaquin Delta waters (Table 3). Proportions of days and anglers changed significantly from 1961 to 1968. A greater proportion of effort was expended by a larger percentage of anglers in fresh waters, whereas the proportions of anglers in other water types and of licensees not fishing decreased correspondingly. Tests which use large sample formulas and which assume normality indicated most differences in numbers and proportions were significant at the 0.05 level. The two exceptions were the increase in number of anglers fishing exclusively in ocean waters and the decrease in the proportion of licensees who did not fish.

TABLE 3

Changes in Estimates Between 1961 and 1968 Surveys

	S.F. Bay and Delta		Fresh water		Ocean	
	Change	S.E.	Change	S.E.	Change	S.E.
Proportion of:						
Angling days	−0.042	0.00292	+0.084	0.00785	−0.042	0.00611
Licensees fishing	−0.036	0.01071	+0.065	0.01249	−0.034	0.01607
Licensees fishing exclusively	−0.020	0.00333	+0.071	0.00955	−0.034	0.01103
Number of:						
Licensees fishing	+43,253	16,776	+502,892	21,705	+195,002	24,817
Licensees fishing exclusively	−17,660	5,236	+308,784	17,191	+14,701	19,052
			Proportion		Number	
			Change	S.E.	Change	S.E.
Licensees not fishing			−0.003	0.01059	+56,698	17,121

ACKNOWLEDGMENTS

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Calif. Fish and Game, 55(4) : 265–272. 1969.

WATERFOWL BOTULISM IN THE SOUTHERN SAN JOAQUIN VALLEY, 1967–68[1]

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A major outbreak of waterfowl botulism occurred in the Kern River Delta area of the San Joaquin Valley, southeastern Kings County, California, during the fall and winter of 1967–68. Approximately 60,000 waterfowl were lost. Some 6,360 sick ducks were treated and survived. The extensive cooperative control program of the U. S. Bureau of Sport Fisheries and Wildlife and the California Department of Fish and Game is described. An estimated 250,000 waterfowl were saved by this program. The outbreak was unusual in that it occurred later in the season than is customary, mid-October 1967 to March 1968.

INTRODUCTION

Over the years botulism, or "western duck disease", has been responsible for the loss of millions of waterfowl and shorebirds along the Pacific Flyway. The Tulare Lake Basin in the San Joaquin Valley has been one of the areas where sizable losses have occurred periodically. Some of the worst outbreaks took place in 1941, 1952, 1958, and, most recently, in 1967. These were described by Mays (1941), McLean (1946), and Rosen and Bischoff (1953). These serious outbreaks coincide with years of excessive spring runoff from the rivers that drain into the basin.

EARLY PREPARATIONS

Early in 1967 it was evident that the heavy rain and snowfall during the winter would provide surplus water in the Kings, Kaweah, Tule, and Kern River drainages. The California Department of Fish and Game organized a meeting of state and federal employees, held on May 25, 1967, in Hanford, California. Twenty-three persons, representing the Department of Fish and Game, U. S. Bureau of Sport Fisheries and Wildlife, U. S. Soil Conservation Service, University of California Agricultural Extension Service, and Fresno Bee (newspaper) were present.

The purpose of the meeting was to (i) identify the problem, (ii) discuss preventive measures and make the necessary assignments to carry them out, and (iii) develop a plan for controlling an outbreak if one should occur.

The importance of preventing the disease from reaching epizootic proportions was emphasized throughout the meeting. Areas that were flooded at that time or likely to be flooded were mapped and assignments to patrol them made. Coordination and communications were planned. The situation had already been explained to the three major landowners controlling most of the potentially dangerous area, and all had promised to cooperate in alleviating the problem. The Soil Conser-

[1] Accepted for publication April 1969. This study was supported by Federal Aid in Wildlife Restoration Project W-52-R, "Wildlife Investigations Laboratory".

vation Service and the Agricultural Extension Service promised to use their influence to obtain landowner cooperation. The following preventive measures were suggested:

1) Disc or burn barley straw or other vegetative matter before irrigation flooding.
2) Maintain ponded areas at a depth of 18 to 24 inches, avoiding shallow water and "feather edges".
3) Move water into another area, by pumps if necessary, whenever conditions indicated that a problem may develop.
4) Herd waterfowl away from problem areas.

In May, most of the Kings River floodwater that could not be diverted north through Fresno Slough was contained in two areas of approximately 13,000 acres within the Tulare Lake Basin (T 22 S, R 20 E, Mount Diablo mer.). Kaweah and Tule River floodwater was concentrated on approximately 27 sections in the Homeland Canal region south of the Tulare Lake bed proper. After the leveed storage areas of Buena Vista Lake were full, surplus Kern River water flooded the Kern River trough area north of Highway 46 to Sand Ridge.

Aerial reconnaissance in May indicated that an estimated 7,200 coots and 1,700 ducks were nesting in Tulare Lake Basin proper and in the Homeland Canal area.

FIRST BOTULISM OCCURS

On July 1, the first dead birds were found, and the Department's Wildlife Investigations Laboratory confirmed that the birds had died of botulism. Coordinated state and federal wildlife agency control plans were put into effect immediately. By this time considerable water had been used for irrigation, and ranchers were able to dry up several potentially dangerous areas. Excellent cooperation from the ranchers was doubtlessly responsible for saving many birds and quite possibly responsible for preventing a serious summer outbreak.

Sec. 13, T 23 S, R 20 E, Mount Diablo mer., Secs. 25 and 36, T 23 S, R 21 E, M.D.M., and Secs. 1 through 6 and portions of 7 through 12, T 24 S, R 21E, M.D.M. were problem areas during July and August. Airboats were used to pick up sick and dead birds from these areas. Other birds attempting to use the area were herded away. Losses, especially of waterfowl, were considered light under the circumstances. Coots and shorebirds were making extensive use of the area throughout the summer, and most of the bird loss occurred in these. Migratory ducks began arriving in August, and in early September an estimated 80,000 ducks were using the Tulare Lake Basin area. By late September all previous problem areas were virtually dry, and the remaining sizable water surfaces were large fields that were being irrigated before seeding crops. These fields were inundated and drained within a period of 5 to 10 days and did not present a botulism problem.

By early October, bird losses had declined, and responsible state and federal employees believed that a serious epizootic had been averted and that any significant outbreak was highly improbable with the advent of cooler weather.

Approximately 1,400 sick and dead birds had been picked up during the summer. Of these, 912 were classified by species (Table 1).

TABLE 1

Birds Lost During July, August, and September, 1967

Species	Number	Species	Number
Mallard, *Anas platyrhynchos*	109	Coot, *Fulica americana*	418
Cinnamon teal, *A. cyanoptera*	49	Black-necked stilt, *Himantopus mexicanus*	145
Pintail, *A. acuta*	42	Avocet, *Recurvirostra americana*	35
Gadwall, *A. strepera*	21	Western grebe, *Aechmophorus occidentalis*	25
Shoveler, *Spatula clypeata*	17	Eared grebe, *Podiceps caspicus*	4
Ruddy duck, *Oxyura jamaicensis*	17	Gull (species not determined)	4
Green-winged teal, *A. carolinensis*	16	Gallinule, *Gallinula chloropus*	2
Ring-necked duck, *Aythya collaris*	1	Dowitcher, *Limnaromus scolopaceus*	1
		Killdeer, *Charadrius vociferus*	1
Total, ducks	272	Least sandpiper, *Erolia minutilla*	1
		Forster's tern, *Sterna forsteri*	1
		Sora rail, *Porzana carolina*	1
		Snowy egret, *Leucophoyx thula*	1
		Ring-necked pheasant, *Phasianus colchicus*	1
		Total, other species	640

MAJOR OUTBREAK

On October 15, 1967, thousands of dead ducks were found in the Kern River Delta (Figure 1), an area that heretofore had not been mapped as flooded (Sections 19, 20, 29, and 30, T 24 S, R 21 E, M.D.M. and Sections 24 and 25, T 24 S, R 20 E, M.D.M.). Subsequent investigations revealed that the landowner was forced to take delivery of approximately 28,000 acre-ft of water that had been stored in Lake Isabella all summer. The delivery was mandatory in order to provide flood storage in Isabella Reservoir for the forthcoming winter. Flooding of four of these sections started on August 31. The remaining two sections were flooded in October. The duck hunting season opened on October 14, and ducks concentrated in this area because it was relatively remote and not hunted.

An immediate all-out effort was made to pick up the sick and dead birds and prevent new birds from using the area, The U.S. Fish and Wildlife Service provided six airboats and crews from refuges as far away as Nevada and Montana. They also transported Job Corps crews (13 men) from Oregon to assist in picking up birds. Dead birds were taken by truck to a dump area for burning. Live birds were treated in a field hospital and transported to a freshwater reservoir some 30 miles from the outbreak. Treatment of sick birds consisted of a freshwater drench, antitoxin injection while the supply lasted, and in some cases a food drench.

AERIAL HERDING

Considerable difficulty was encountered in herding ducks away from the Kern River Delta ponded area. Sick and dead birds were subsequently found in Sections 1 through 12 and Section 16. Although there were indications that some of these areas were toxic, it could not be determined exactly where the birds were picking up the toxin. It was therefore necessary to try to keep the birds from using the entire area.

Aircraft from both state and federal wildlife agencies were used to herd ducks away from the problem area throughout the fall and winter. These efforts were concentrated on Wednesdays, Saturdays, and Sundays, because there was normally a greater movement of ducks on these days, when hunting occurred on private clubs and public shooting

areas. The U. S. Air Force provided a helicopter on two occasions; and late in the winter, when it became difficult to get agency planes, a contract was let with a local flying service to assist with the herding. Aerial herding efforts achieved varying degrees of success, depending on several factors. Generally speaking, herding efforts were most successful when at least three airboats were coordinated with two aircraft. Poorer results were obtained when less equipment was available or when the airboats were not coordinated with the aircraft. There were times when the effort by a single aircraft and one or two airboats seemed

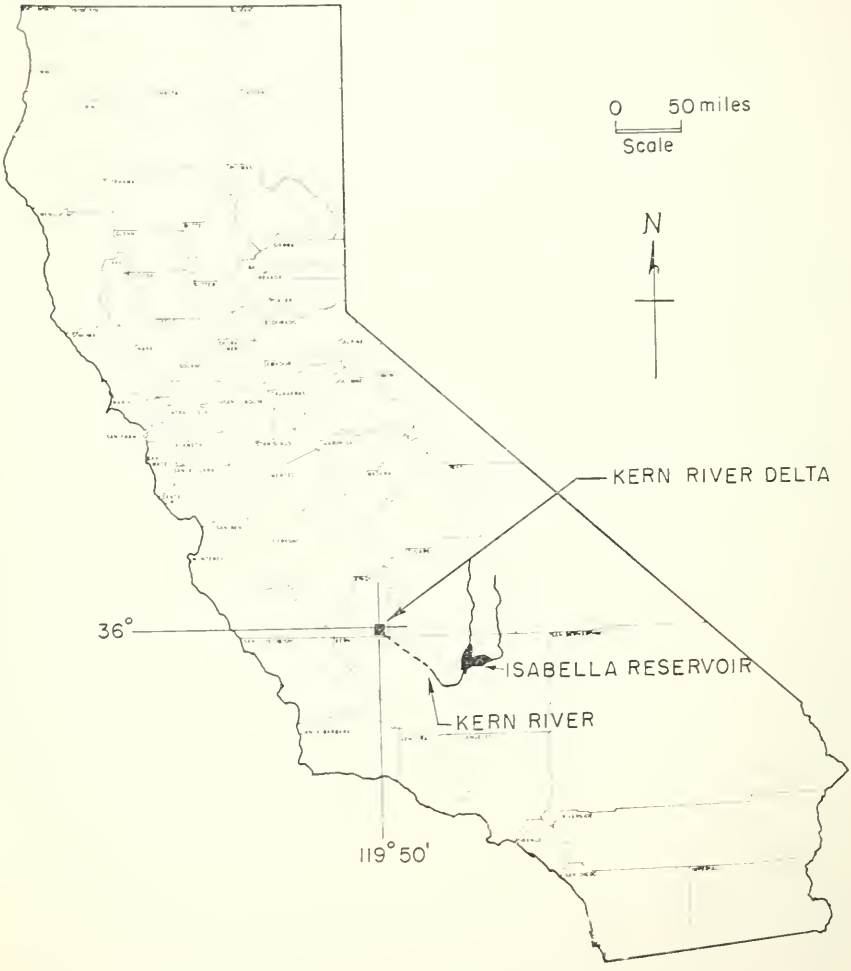

FIGURE 1—Location of the major outbreak of botulism in 1967–68.

futile. A greater degree of success was achieved when the ducks could go to an attractive place where they were not harassed.

The fact that many ducks returned to the toxic area at night presented an additional problem. The local contractor, flying at low alti-

tudes and switching the landing lights off and on, appeared to be successful in frightening ducks from the area in the only attempt at night herding. Night herding was not continued because of the hazards involved.

Flying conditions were considered hazardous because (i) large numbers of birds were in the air, (ii) at times it was easy to lose the horizon over the expanse of smooth water, and (iii) shotguns and cracker shells were sometimes used from the plane.

FRIGHTENING DEVICES

Several methods were used to keep waterfowl and other birds from the area. The success of any one method varied from time to time, but generally speaking a scare device was more effective when first used or used at a new location. Automatic acetylene and butane poppers were used throughout the problem area and were relocated from time to time. Other scare devices used at one time or another included (i) cracker shells fired from land, airboat, or aircraft, (ii) cherry bombs, used chiefly on punk ropes, arranged to go off throughout the day or night, (iii) construction blinkers placed at strategic locations, and (iv) a 12-volt light used on an airboat. The use of military dyes on the water and high-powered rifles was considered but not effected.

REFUGE CLOSURE

During the latter part of October, field personnel encountered considerable difficulty in keeping waterfowl off the problem area. It was apparent that the ducks needed an attractive nearby area where they would not be harassed. The 4,328-acre Pixley National Wildlife Refuge, 15 miles northeast, allowed no hunting, but was not large enough or attractive enough to do the job.

Kern National Wildlife Refuge, 4 miles south, was open to public hunting on Sundays, and the decision was made by state and federal officials to close the refuge to hunting beginning November 12, 1967. Undeveloped portions of the refuge were flooded to provide additional resting areas which would make it more attractive. This was made possible by purchase of 7,000 acre-ft of water by the Bureau of Sport Fisheries and Wildlife. The complete closure of the refuge improved the effectiveness of the herding program almost immediately. Most of the 80,000 to 100,000 ducks using the refuge remained there as long as the feed lasted. Although the value of the refuge closure diminished as the season progressed, this greater than usual number of birds using the refuge started feeding flights to the south into the Buena Vista Lake area, where rice stubble was located. The refuge was not hunted for the remainder of the season.

PICKUP OF DEAD BIRDS

When the major outbreak occurred in the Kern River Delta, an all-out effort was made to clean up the dead birds. This was done to reduce the hazard to live birds of feeding on toxin-containing blowfly maggots. The weather was warm, and the carcasses were blown by flies almost immediately. Hundreds of acres of extremely shallow water made the pickup quite difficult. The use of pitchforks handled from airboats was

the most feasible way to retrieve many of the birds. Both wildlife agencies hired temporary help to assist permanent personnel in the pickup. Kings County made $1,600 available for temporary labor. Ninety-one man-days were made available by the Job Corps, and the California Division of Forestry provided 213 man-days of inmate labor from the Mt. Home Conservation Camp.

The dead birds were tabulated by species for the first few days (Table 2), but this practice was soon dispensed with to conserve time. The early species composition is a good general indicator of relative numbers lost, but some changes occurred later in the season. Losses of late-arriving divers and shovelers increased somewhat as the season progressed. Ruddy ducks were virtually impossible to herd from the area, which contributed to mortality of this species. There was an apparent disproportionate large loss of males, especially among pintails. No tally of sex of lost birds was made, however.

TABLE 2

Species Sample from Major Botulism Outbreak in the Kern River Delta

Species	Number	Percentage	Species	Number	Percentage
Pintail, *Anas acuta*	1,607	82.5	Mallard, *A. platyrhynchos*	12	0.6
Green-winged teal, *A. carolinensis*	200	10.2	Gadwall, *A. strepera*	4	0.2
Shoveler, *Spatula clypeata*	73	3.7	Cinnamon teal, *A. cyanoptera*	3	0.2
Widgeon, *Marrca americana*	29	1.5	Lesser scaup, *Aythya affinis*	3	0.2
Ruddy duck, *Oxyura jamaicensis*	17	0.9	Ring-necked duck, *Aythya collaris*	1	---
			Total	1,949	100.0

By the middle of November, crews had cleaned up most of the initial losses, and records were then kept on a daily basis. As the outbreak continued, loss intensity decreased (Table 3).

By the middle of March, most of the waterfowl had left the area on their northern migration, and losses had diminished to the point that the bird pickup operation was suspended. Subsequent checks of the area indicated that there was a small continuing loss of shorebirds, but waterfowl losses appeared to be negligible. By March 18, 1968, a total of 57,864 sick and dead birds had been picked up; 6,360 of the treated birds apparently survived, leaving the known loss at 51,504. No effort was made to pick up or count carcasses on much of the agricultural and native grassland adjacent to the problem area, and the estimated loss was probably 5,000 to 10,000 more than the count.

TABLE 3

Trend of Bird Losses Throughout the Outbreak Period

Date	Sick and dead birds picked up to date	Interval losses	Date	Sick and dead birds picked up to date	Interval losses
Nov. 12, 1967	40,577	6,383	Feb. 4, 1968	56,480	1,283
Dec. 4, 1967	46,960	6,809	Mar. 4, 1968	57,763	101
Jan. 4, 1968	53,769	2,711	Mar. 18, 1968	57,864	

LABORATORY INVESTIGATIONS

The primary botulism problem area was six sections of Kern River Delta land containing 28,000 acre-ft of water. This land had not been flooded previously for 10 years. The flooded sections were adjacent and formed a ponded area 2 miles wide and 3 miles long, with the deepest part, in the center, 3 to 4 ft deep. The water gradually became shallower toward the edges, creating a mudflat along the shoreline.

Periodically during the course of the outbreak, observations and tests were made of the water and substrate to discover where the botulism toxin was being produced. However, the toxin could be demonstrated only in the carcasses of dead birds and in blowfly larvae in and around the carcasses.

The water was clear and free of heavy growths of algae. The only appreciable organic material in the water was some barley stubble in parts of Sections 29 and 30.

Dissolved oxygen levels in the pond during the day were never below 4 ppm and rose as high as 11 ppm. Water temperatures during the early part of the outbreak in October were 74 F maximum and gradually decreased as the fall and winter progressed. During the winter a skim of ice formed around the edges of the ponds during the coldest nights. The pond water pH was 7.4.

No explanation of what served as the growth substrate for the *Clostridium botulinum* Type C bacteria can be given at this time. It is believed that the severe winter outbreak was primarily due to toxin formed during the fall. It is assumed that there must have been a tremendous bloom of botulism organisms during late September and early October. Most of the toxin formed during warm weather would remain within the bacteria and not be released until autolysis occurred. Because of the drop in temperature the bacterial metabolic rate would have been lowered, thus prolonging the time between toxin production and autolysis and subsequent toxin in sufficient quantities to cause a late-season epizootic.

This outbreak was quite unusual in comparison with past observed botulism outbreaks. It started very late in the year and continued in severity throughout the coldest part of the winter. The average maximum air temperature during September was 90 F, the average minimum 60 F. By November, average maximums were 72 F and minimums 42 F. December was much colder, with temperatures frequently below freezing at night, with a low of 20 F recorded.

During the coldest weather the area remained extremely toxic, killing birds overnight. Autopsied ducks were fat and showed no signs of chronic illness, unlike those in the usual case of winter botulism.

COST OF BOTULISM CONTROL

The estimated cost of control operations in the Kern River Delta for all agencies involved was nearly $83,000 (Table 4). Despite this massive control effort, approximately 60,000 waterfowl died from botulism. However, it is likely that without these efforts an additional 250,000 or more waterfowl would have been lost.

TABLE 4

Cost of Botulism Control

Agency	*Cost*	
California Department of Fish and Game		
Field operations—salaries, wages, expenses	$29,293.00	
Staff services—research and investigations	8,400.00	
Department airplane expense	5,393.00	
Contracted aerial herding	808.00	
Administrative costs	4,160.00	
Total		$48,054.00
California Division of Forestry (inmate labor)	745.00	
Kings County (county fine money)	1,600.00	
U. S. Bureau of Sport Fisheries and Wildlife	32,600.00	
Total		$34,945.00
Grand total *		$82,999.00

* Costs do not include wear and tear on equipment.

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COMPARISONS OF DISK-DANGLER, TRAILER, AND PLASTIC JAW TAGS[1]

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Survival, condition, tag-induced irritation, and shedding were evaluated for three types of tags in two hatchery pond experiments. Tags were tested with three varieties of trout: domestic rainbow (*Salmo gairdnerii*), Kamloops rainbow (*S. g. kamloops*), and Lahontan cutthroat (*S. clarkii henshawi*). In the first experiment, disk-dangler and trailer tags secured with 0.012-inch diameter stainless steel wire and 0.015- and 0.020-inch diameter tantalum wire were compared. In the second experiment, trailer tags with cellulose nitrate, vinyl plastic, and hydrostatic pennants were compared with plastic jaw tags. Trailer tags attached with 0.015-inch tantalum wire and plastic jaw tags were shed most frequently. Differences between the various dangler and trailer tags were slight, but trailer tags of 0.012-inch diameter stainless steel wire with vinyl plastic pennants were considered best for experiments with rainbow trout when much growth was expected.

INTRODUCTION

During investigations by the Lake Tahoe Fisheries Study, it became apparent that a tagging program was needed to evaluate returns of trout planted in the lake. A tag that trout would retain for several years and that would allow for substantial growth by the tagged fish was needed. A literature review suggested two promising tags: the disk-dangler tag and the Swedish trailer or Carlin tag. We decided to test these plus a plastic mandible tag in a hatchery pond at the old Tahoe State Fish Hatchery near Tahoe City, California.

The requirements of a successful tag are summarized by Chadwick (1963). In our experiments, we were primarily interested in determining (i) the tag's effect on mortality, (ii) the degree of shedding, and (iii) how well it retained its visibility and legibility. The criteria we employed to judge the suitability of the tags were (i) survival and condition factors, (ii) shedding rate, (iii) tag-induced irritation, and (iv) growth of flesh over tags. This report presents the results of these tests.

The disk-dangler tag was first described by Calhoun (1953). Since then it has been used successfully on a variety of freshwater and anadromous fishes by the California Department of Fish and Game. Before our tests, however, it had not been tested on salmonids. The trailer tag was developed in Sweden to evaluate the survival of Atlantic salmon (*Salmo salar*) smolts (Carlin, 1955). Chadwick (1966) describes these and other tags.

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As originally designed, the dangler and trailer tags have many similarities. Both consist of a pennant attached to a double-wire frame. They can be applied in the same manner and at the same location. However, the significant feature of the trailer tag is a link connecting the frame to the pennant. This permits extensive growth of the fish without obscuring the pennant, and whereas the pennant of the dangler tag is rigidly attached to the frame, the pennant and link of the trailer tag oscillate about the frame, hanging down as the fish rests, and trailing back as the fish swims. Also, the wire and pennant of the trailer tag are considerably smaller than those of the dangler. Finally, trailer pennants are oblong, whereas dangler pennants are circular. For this study, both tags were modified as described below.

The jaw tag used in this experiment is a coiled, plastic "bandette" capable of expanding as the trout's jaw grows larger.

METHODS AND MATERIALS

General

Two experiments were conducted. In the first, the dangler and trailer tags constructed with stainless steel and tantalum wire were tested with domestic rainbow, Kamloops rainbow, and Lahontan cutthroat. In the second experiment, domestic rainbow trout were used in comparisons of trailer tags attached with one wire type but using three different types of pennants. These were also compared with the jaw tag and an untagged control.

Trout were first anesthetized in tricaine methanesulfonate (MS-222), and then transferred to wooden tagging cradles lined with foam rubber for tagging. The dangler and trailer tags were applied by pushing two 20-gauge, 1½-inch hypodermic needles through the dorsal musculature at a point below the base of the anterior half of the dorsal fin and about one-third the distance between it and the lateral line. The two tag wires were threaded into the hypodermic needles and pulled through the fish as the needles were withdrawn. The two ends were then twisted together and the excess removed (Figure 1). The first needle was inserted perpendicular to the midline of the body, while the second needle was inserted anteriorly and at an angle such that it emerged at the same point on the tag side as the posterior needle. This was recommended by Kimsey (1956) to improve stabilization of the wires. On the knot side, the two wires were about ½ to ⅝ inch apart. A spacer was used to maintain this distance. Thus, one or more proximal pterygiophores were encompassed, serving to help anchor the tags. The link and all twists were about ½ to ⅝ inch long.

Jaw tags were applied through an incision made in the skin between the mandible and the isthmus. The coiled tag was spread apart by hand and one end was pushed through the incision. When the tag was released it sprang back to its original coiled position in place around the mandible.

Jaw tags were applied at the rate of about 60 fish per man-hour, approximately twice as fast as dangler and trailer tags could be applied (33 fish per man-hour). Although trailer and dangler tags could be applied with equal speed, trailer tags took considerably longer to fabricate because of the link.

The pond in which the tagged fish were held was an earthen-wall excavation approximately 52 ft long, 18 ft wide, and 3 ft deep. Water, taken from a spring, ranged from 40 to 45 F and 1 to 3 ft^3/sec the year around. All fish were fed commercial dry pellets twice daily at a somewhat higher rate than recommended by Leitritz (1959), in order to produce rapid growth. The pond was checked daily for shed tags and dead fish, and appropriate observations and measurements were made. At tagging and upon each examination, lengths and weights of the trout were recorded and the condition of the tag and tag wound was noted. All trout were measured to the nearest 0.1 inch FL and weighed to the nearest 0.01 lb.

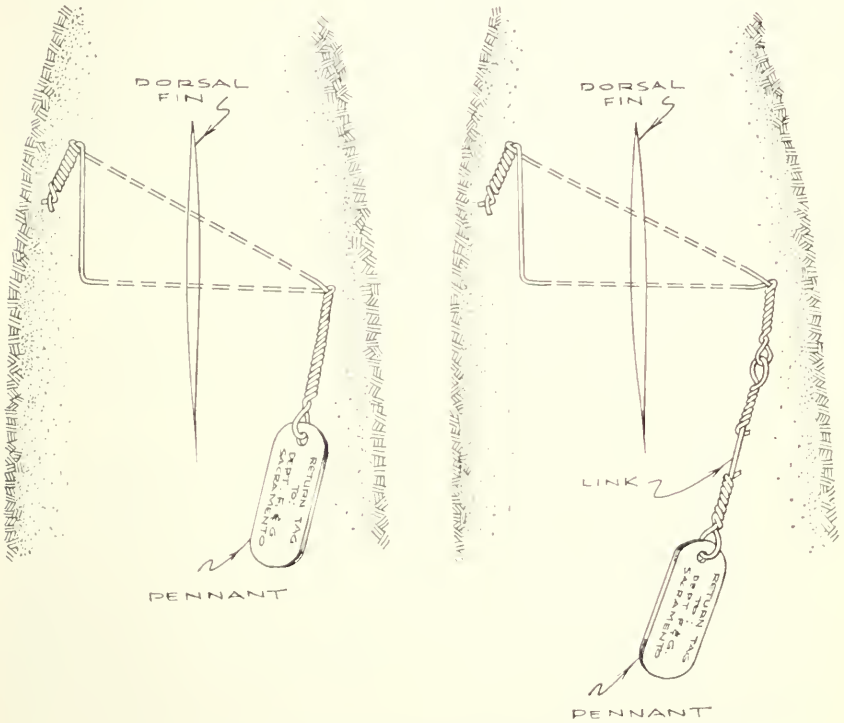

FIGURE 1—Diagrammatic dorsal view of disk-dangler tag (left) and trailer tag (right) in attached position (head of trout toward top).

Experiment I

The dangler tag was identical to that described by Chadwick (1963) except that the pennant was oblong instead of circular. The trailer tag we used resembled the original Swedish or Carlin tag only superficially. The framework was triangular rather than rectangular, and the pennant was much larger. Basically, our trailer tag is much heavier than the original Swedish type and might best be described as a disk-dangler modified by the addition of a link. We needed the capacity of the larger pennant to hold the legend we anticipated using in the field. Also, we assumed it would not burden the relatively large trout

we would be tagging (8 to 12 inches). The Swedish tag is customarily applied to small salmonids (4 to 6 inches).

The pennants for both the dangler and trailer tags were constructed of laminated green vinyl plastic and were $\frac{1}{4}$ inch wide, $\frac{5}{8}$ inch long, and 0.05 inch thick. Soft stainless steel 0.012 inch in diameter and tantalum 0.015 inch and 0.020 inch in diameter were the wire types tested with each tag type and species.

Tagging began on March 25, 1963, and was completed on June 10, 1963. A total of 297 trout was tagged.

Experiment II

The trailer tag with 0.012-inch stainless steel wire was tested with pennants of green vinyl plastic identical to that used in the first experiment, laminated white cellulose nitrate, and the Einar Lea hydrostatic pennant. Cellulose nitrate pennants had the same dimensions as those made with vinyl plastic. The hydrostatic pennants were identical to those developed for the original Einar Lea hydrostatic tag (Rounsefell and Everhart, 1953) and were $1\frac{3}{8}$ inches long by $\frac{5}{16}$ inch in diameter. The blue jaw tags were $1\frac{3}{4}$ inches long by $\frac{1}{32}$ inch thick.

One hundred of each treatment group were tagged on August 12, 1964. Controls were marked by removal of the adipose fin.

Evaluation

Fish tagged in experiment I were examined on November 21, 1963, July 31, 1964, and August 23–24, 1965. Experiment II fish were not examined again until August 23–24, 1965. Both experiments were terminated at that time.

Growth of the fish over the tag and displacement of the tag in the flesh was determined by noting how far each side of the tag had been covered by the flesh or how far each side of the tag had shifted out of the flesh. These were judged quantitatively by assigning numerical rankings according to the length of tag visible. The score for each fish was the sum of the rankings for both the tag and knot sides. Observations were made of tag wounds on both sides of the fish to determine the amount of tag-induced irritation. The wound area was measured in mm^2 and rankings were applied according to the degree of seriousness. Again, the total score for each fish was a sum of the tag- and knot-side rankings.

RESULTS

Experiment I

Survival and Condition

Each species of trout tested exhibited different rates of survival and condition in the hatchery pond. Domestic rainbow had the highest survival, with Kamloops showing intermediate survival, and Lahontan cutthroat showing the poorest (Table 1). Differences in the percentage survival between each examination period were not statistically significant. However, differences in the overall survival from tagging to the end of the experiment were highly significant ($\chi^2 = 20.69$, $P < 0.01$).

The effects of the various combinations of tag, wire type, and wire size on survival were not distinct nor consistent between examination

TABLE 1

Survival of Tagged Trout in Hatchery Pond, Experiment I

	Domestic rainbow			Kamloops rainbow			Cutthroat		
	Number	Percentage survival between periods	Mean length	Number	Percentage survival between periods	Mean length	Number	Percentage survival between periods	Mean length
Number tagged 3/63–6/63	96	----	11.31	122	----	12.10	79	----	9.15
Tagged fish remaining 11/21/63	91	94.8	14.39	100	82.0	13.67	54	68.4	9.97
Tagged fish remaining 7/31/64	86	94.5	15.95	82	82.0	15.81	41	75.9	10.88
Tagged fish remaining 8/24/65	55	64.0	17.66	40	48.8	16.66	13	31.7	11.52
Overall survival	55	**57.3**	----	40	**32.8**	----	13	**16.4**	----

TABLE 2

Overall Percentage Survival of Tagged Trout in Hatchery Pond, Experiment I, by Treatment Group and Treatment Group Combination

	0.012 Stainless steel		0.015 Tantalum		0.020 Tantalum		0.012 Stainless steel	0.015 Tantalum	0.020 Tantalum	Trailer tantalum	Dangler tantalum	Trailer	Dangler
	Trailer	Dangler	Trailer	Dangler	Trailer	Dangler							
Domestic rainbow	55.6	53.3	31.2	68.8	75.0	60.0	51.5	50.0	67.7	53.1	64.5	54.0	60.9
Kamloops rainbow	21.7	16.7	33.3	47.6	35.0	42.1	19.7	40.5	38.5	34.1	45.0	29.7	36.2
Cutthroat	14.3	16.7	14.3	36.4	6.2	16.7	15.4	24.0	10.7	10.0	26.1	11.1	22.8

periods or species. This indicates that tag and wire effects were not significantly different from one another, and that the species effect had a greater influence on survival. The group with the best overall survival for the domestic rainbow was the trailer 0.020-tantalum group (Table 2). This group, however, gave the poorest results for cutthroat. The best survival for this species, and the Kamloops rainbow as well, was the dangler 0.015-tantalum group.

The mean condition factor for cutthroat was significantly lower than the factors for the rainbow. However, this difference occurred only at the time of tagging and was not detectable at subsequent examinations. Thus, it appears that the tag and wire types tested had no significant effect on the condition of the trout.

Growth of Flesh Around Tags

The cutthroat trout grew very slowly (Table 1) and thus showed the least amount of growth over the tags. Domestic and Kamloops rainbow exhibited considerable growth over the tag, but there was little difference between them. Figure 2 shows how the flesh of a domestic rainbow trout grew about half way over the pennant, in this case, of a dangler tag. When the ranking data for the first and second examination dates were compared, the trailer-tagged trout consistently showed less growth over the tag than their dangler-tagged counterparts, except for the cutthroat on July 31, 1964. Considering only rainbow trout, we observed that the flesh did not begin to grow over the pennant of the trailer tags until the final examination date, when the average length of these fish had increased from 11.6 inches at tagging to 17.1 inches. Growth of the trout over the dangler tags, however, began at about the time of the first examination, when the average length of these rainbow had increased from 11.9 inches to 13.6 inches. Corresponding weight gains for these groups were 0.78 to 1.21 and 0.76 to 2.13 lb, respectively.

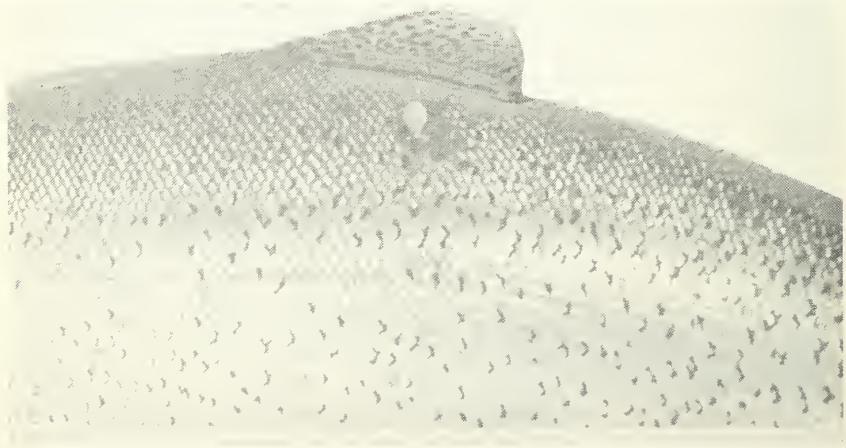

FIGURE 2—Pennant of disk-dangler tag in the process of being covered by dorsal musculature of domestic rainbow trout. This fish was 12.8 inches (0.91 lb) at tagging and when photographed 14½ months later (July 31, 1964) was 20.6 inches (4.38 lb). *Photograph by Almo J. Cordone.*

The majority of the trout examined exhibited growth over both the tag side and knot side of the tags. In contrast, growth apparently took place only on the knot side of disk-dangler tags attached to striped bass, *Roccus* (now *Morone*) *saxatilis* (Chadwick, 1963).

Degree of Irritation

In general, there was a substantial increase in the amount of tag-induced irritation from November 21, 1963, to July 31, 1964, but by the final examination date most wounds had healed. We found no significant differences in the effects of each of the treatment combinations on tag-induced irritation. Internally, there was little evidence of irritation with either the stainless steel or tantalum wires.

Shedding

At least six different causes of shedding were observed during the experiment (Table 3). The trailer 0.015-tantalum group experienced the highest rate of shedding, which was significantly greater than that of any of the other groups ($\chi^2 = 24.36$, $P < 0.01$). Breakage of the link was the main cause of these losses. "Pulling out" was the next most frequent cause of shedding, occurring with greatest frequency in the trailer 0.012-stainless steel group. Actually, those that became "untwisted" also pulled out. Untwisting of the knot occurred only with stainless steel. This is probably due to its greater resiliency and smoothness compared with tantalum.

Dangler 0.015-tantalum and dangler 0.012-stainless steel had the best tag retention. There was no significant difference in the shedding rate between trout strains.

Experiment II

The noticeably lower survival of the hydrostatic and jaw-tagged fish (Table 4) was not significantly different from survival of the other groups. Nor were there any significant differences in mean length and condition factor at the end of the experiment.

Differences between growth of the flesh over the tags and tag-induced irritation for each tag group (except the jaw tagged trout) were insignificant. Jaw tags could not be directly compared with the trailer tags. However, they did cause considerable irritation, and in virtually every instance the mandible showed a definite constriction and an open wound at the tag site.

Only 8 of the 400 tags applied in this experiment were shed during the year in the hatchery pond (Table 4). Seven were plastic jaw tags, of which 5 broke and 2 pulled off but remained intact. One hydrostatic tag was shed as a result of a broken wire. Differences in the observed shedding rates (control group excluded) were highly significant ($\chi^2 = 15.00$, $P < 0.01$).

The cellulose nitrate-tagged trout gave overall results similar to the vinyl plastic-tagged trout. Pennants of the former, however, became illegible due to periphyton growths.

DISCUSSION

The most significant basis for evaluating the performance of the different tags and wire types was found to be the shedding rate. The effects of the tag and wire types on survival and condition, the growth

TABLE 3

Number of Tags Shed and Cause of Shedding by Tagged Trout in Hatchery Pond, Experiment I, by Treatment Group and Treatment Group Combination

	0.012 Stainless steel		0.015 Tantalum		0.020 Tantalum		0.012 Stainless steel	0.015 Tantalum	0.020 Tantalum	Trailer tantalum	Dangler tantalum	Trailer	Dangler
	Trailer	Dangler	Trailer	Dangler	Trailer	Dangler							
Number shed	6	3	15	2	4	5	9	17	9	19	7	25	10
Broken link	1	0	13	0	1	0	1	13	1	14	0	15	0
Pulled out	3	0	2	1	1	2	3	3	3	3	3	6	3
Broken wire	0	1	0	0	1	1	1	0	2	1	1	1	2
Broken tag	0	0	0	1	0	1	0	1	1	0	2	0	2
Untwisted	2	1	0	0	0	0	3	0	0	0	0	2	1
Unknown	0	1	0	0	1	1	1	0	2	1	1	1	2

TABLE 4

Survival, Condition, and Shedding of Tags of Tagged Trout in Hatchery Pond, Experiment II

Tag	Number tagged	Mean length	Number survived	Mean length	Mean condition	Percentage survival	Number of tags shed
Vinyl plastic	100	9.16	75	12.55	45.18	75	0
Cellulose nitrate	100	9.18	74	12.68	45.63	74	0
Hydrostatic	100	9.28	64	12.60	45.94	64	1
Jaw	100	9.25	68	12.29	44.47	68	7
Control	100	9.10	74	12.74	45.42	74	--

of the flesh over the tag, and tag-induced irritation are relatively minor and are overshadowed by differences in these characteristics inherent within the species. These results are not surprising when the similarity of the tags and the method of application are considered. Chadwick (1963) used three wire types in tests with disk-dangler tags on striped bass: 0.020 stainless steel and 0.020 and 0.025 tantalum. He found no significant differences in the returns of 0.020 and 0.025 tantalum, but the 0.020 stainless steel and 0.020 tantalum gave variable returns in three different years. He also found little difference in the irritation caused by 0.020 stainless steel and 0.020 tantalum, with greater, though not significant, irritation caused by 0.025 tantalum.

Saunders (1968) tested Swedish trailer tags with three types of attachment "wires": stainless steel, polyethylene filament, and surgical suture. He found that tags attached with stainless steel wire caused severe abrasion on Atlantic salmon smolts, but the percentage recapture of this group was significantly higher than that of filament- and suture-tagged smolts. He could not determine whether this difference was due to higher survival of stainless steel-tagged salmon or higher shedding rate of the other groups.

Shedding appears to be independent of any species influences and entirely dependent on tag and wire type, with trailer 0.015 tantalum suffering the greatest loss. It is likely that oscillation of the trailer tag at the link caused the tantalum wires to break. However, only 0.015 tantalum was involved, since the differences between trailer and dangler 0.020 tantalum, and trailer and dangler 0.012 stainless steel, were not significant. Although Skinner and Calhoun (1954) found that there was no significant difference in the proportion of stainless steel and tantalum wire Petersen tags returned from striped bass, they did observe that repeated bending caused 0.032-inch tantalum wire to break much more readily than soft stainless steel of the same diameter. This would explain why the dangler and stainless steel tags broke with much less frequency, but would not explain why the trailer 0.020 tantalum links did not break with greater frequency. It is possible that had the experiment been carried on longer, the trailer 0.020 tantalum wires would have begun breaking at the link, since their greater thickness probably would require a longer period of wear before breaking. This is supported by the fact that 10 of the 15 trailer 0.015 tantalum tags were not shed until between the second and third examinations (14–27 months). In fact, a general increase in shedding rate with time was observed for all tag types, with 57% of the total shed between the second and third examination dates. Chadwick (1963) working with striped bass, also found an increase in shedding rate with time.

The second major cause of shedding was the tag simply pulling out of the flesh. To what degree oscillation of the link in the trailer tag contributed to shedding is not known, but there was a slightly greater tendency for trailer tags to pull out of the flesh than dangler tags. Those tags that pulled out were found with the wires close together, indicating that they had worked through the flesh and come together before being shed. There was no evidence, however, that loose tags caused internal hemorrhaging or infection any more than tightly-held tags.

High retention of both the dangler and trailer tags illustrates the suitability of the frame shape. Dissection of the tag area on a large number of trout tended to confirm Kimsey's (1956) recommendation that placing the wires in a triangular shape rather than a rectangular shape would improve stabilization and reduce internal irritation. No pockets of necrotic tissue were found, and there was only slight evidence of localized necrosis along the wires. However, although the wires seemed to stabilize well, some initial displacement occurred. The anterior wire stabilized in a position approximately perpendicular to the midline of the body, and the posterior wire stabilized in the form of a loop on the knot side, extending ventrally and posteriorly and forming a shallow angle with the anterior wire on the tag side. On the other hand, the conventional Swedish trailer tag utilizes the rectangular frame, and nothing was found in the literature to indicate a stabilization problem.

Because the only difference in the trailer tags tested in experiment II was the type of pennant, it is not surprising that there were no significant differences in the effects of these tags on the trout. The hydrostatic pennants appeared less suitable than the vinyl plastic and cellulose nitrate pennants because they caused lower survival and greater irritation. It was thought that the greater irritation may have been caused by the continual motion of the buoyant pennant. However, Chadwick (1963) compared disk-dangler tags with conventional and hydrostatic pennants and found that irritation was much reduced with the latter, and probably would have been significantly less had there been more recaptures to analyze. He attributed the lesser irritation to the lower resistance of the pennant in water, having a specific gravity nearly equal to that of water itself. However, the striped bass he tagged were considerably larger than the trout we used. The continual motion of the hydrostatic tag, it seems, would have a more serious effect on smaller fish.

While the cellulose nitrate pennants were similar to the vinyl plastic pennants, their tendency to become covered with periphyton would make them less suitable, especially when tags are to be returned by fishermen.

Although the jaw-tagged trout experienced the lowest survival and highest shedding of any other group, they gave better results than those reported in some other studies of jaw tags (Kimsey, 1956; Whitney, 1958; Eschmeyer, 1959; Nelson, 1960), the most important criterion being the shedding rate. However, the fact that jaw-tagged trout grew the least, suggests that these tags would seriously retard the growth of the trout in the wild. Therefore, it appears that the plastic bandettes, while they will expand as the fish grows, will not offer much advantage over other jaw tags.

It is unsafe to assume that pond test results will be duplicated in the wild. Although there was no indication in experiment II that trailer tags retarded growth, tags of both the dangler and trailer type are known to do so under field conditions (Chadwick, 1963; Saunders and Allen, 1967). The question of wounds is even more complex.

We observed few serious wounds in the pond tests, particularly for the two rainbow species. Wounds tended to be small, and then

healed as growth progressed. Subsequent field trials of trailer and dangler tags in Lake Tahoe indicated no serious wound problems. However, although wounds did not develop under hatchery conditions, Saunders (1968) reported a high incidence of severe wounds from chafing of the pennant (trailer tag) against the side of Atlantic salmon smolts in the wild. Of returning adults, Saunders wrote, "On the side of the fish from which the growth sector protruded, there was always a wound, . . . in the form of a crater . . ., probably formed through action of the tag label, which caused the growth sector to describe a conical path in its movement. Dr. Carlin (personal communication) suggests that when wounds occur at the point of attachment, the cause may be that the tag was attached too low." Recently, a very similar type of wound was reported from angler-caught rainbow trout stocked in Shasta Lake, California. The tag used on these fish was identical to the trailer tag with stainless steel wire used in our pond studies. This implies that the performance of a tag in one body of water may not necessarily be attained in another.

Very similar results were obtained with both the dangler and trailer tags. For tagging experiments with rainbow trout, the trailer tag would be more suitable when a large amount of growth is anticipated. However, if little or no growth is expected, the dangler would obviously be the best choice. Because of less breakage, stainless steel wire is recommended over tantalum. Vinyl plastic pennants were superior to both hydrostatic and cellulose nitrate pennants. There was greater irritation with the hydrostatic tags and periphyton growths were a problem with cellulose nitrate. Also, the cellulose nitrate pennants were more expensive and more difficult to obtain because of the extreme fire danger involved in their manufacture.

The poor survival and growth of the cutthroat trout, we believe, was independent of any tag effects. The Lahontan cutthroat is very difficult to raise in California hatcheries beyond the fingerling stage. It is not possible to state from these results whether the shedding rate and irritation of these tags would be different from that observed for the rainbow trout, but the trailer and dangler tags with stainless steel wire should also be suitable for cutthroat captured and released in the wild.

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DISTRIBUTION, SIZE COMPOSITION, AND RELATIVE ABUNDANCE OF THE PIUTE SCULPIN, *COTTUS BELDINGII* EIGENMANN AND EIGENMANN, IN LAKE TAHOE[1]

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Piute sculpins were collected in Lake Tahoe mainly with otter and sled trawls. Night otter trawls caught significantly more fish than day trawls. In rocky areas along the shoreline, fish were taken with rotenone. Sculpins were taken from very shallow water to depths of 700 ft. Largest concentrations occurred at depths less than 200 ft. The substrate appeared to affect sculpin densities considerably. Largest numbers were found in rock and rubble and on the steeper slopes. Sandy or muddy bottoms with little gradient usually yielded the fewest. Significant variations in year-class strength between different lake areas suggested that the Piute sculpin is not far ranging. Species composition of otter trawl catches indicates that the sculpin is one of the most abundant fishes in Tahoe. Only the tui chub (*Gila bicolor*) was captured in greater numbers in trawls at depths less than 300 ft. At depths of 300 ft and greater, the sculpin was the most abundant.

INTRODUCTION

This is one of a series of papers reporting the findings of the 6-year Lake Tahoe Fisheries Study. The study, initiated in 1960 as a cooperative effort between the California and Nevada Departments of Fish and Game, investigated the lake's fisheries, the life histories of its fishes, and certain aspects of its ecology. This paper presents the findings relating to the distribution, size composition, and relative abundance of the Piute sculpin. Ebert and Summerfelt (1969) discuss other aspects of its life history.

Eigenmann and Eigenmann (1891) originally described the Piute sculpin from Tahoe specimens. It has since been found throughout the Lahontan Basin of California and Nevada, and in the Bonneville and Columbia River drainages as well (La Rivers, 1962). Portions of the sculpin's life history in Tahoe have previously been described by Miller (1951). His study was based mainly on shallow water collections and stomach analyses of piscivorous fishes. This report confirms many of his findings and presents additional data.

Lake Tahoe, located on the California-Nevada border at an altitude of 6,229 ft, is a large, deep, and extremely oligotrophic alpine lake. It covers 123,300 surface acres, and has maximum and mean depths of 1,645 and 1,027 ft, respectively. Dissolved solids generally range between 60 and 65 ppm, and Secchi disk readings are usually 75 to 100 ft. McGauhey et al. (1963) describe the physical and chemical features of Lake Tahoe in detail.

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METHODS AND MATERIALS

A number of methods were used to sample the diversity of fishes and habitats in Lake Tahoe. These included otter, sled, and midwater trawling, bottom and open-water gill netting, minnow trapping, seining, and rotenone treatment. Of these, otter trawling was the most effective method for collecting sculpins, particularly from depths of 100 to 500 ft. Nearly 98% of the 7,390 sculpins collected were taken by this method. A small sled trawl described by Linn and Frantz (1965) was very effective in capturing sculpins in shallow water. Unfortunately, this trawl was used very little, since its value did not become apparent until late in the study. Approximately 60 sculpins were taken by this method. Virtually all of the remaining sculpins were obtained by rotenone treatment in the shallow shoreline areas. This procedure was described by Baker (1967). Lastly, two sculpins were captured in bottom gill nets.[3]

The semiballoon otter trawl used in this study was made by the Marinovich Trawl Company of Biloxi, Mississippi. The width of its mouth was 25 ft measured along the headrope. The mesh sizes in the body of the trawl and in the cod end were $1\frac{1}{2}$ and $\frac{1}{2}$ inches (stretch measure), respectively. The former was made of No. 9-thread nylon, and the latter was of cotton. In addition, a skirt of $1\frac{1}{4}$-inch mesh No. 15-thread nylon protected the cod end. Mahogany trawl doors, 15 by 32 inches; 1,800 ft of $\frac{5}{32}$-inch trawl cable; and 100-ft long, $\frac{1}{8}$-inch diameter trawl bridles were the other major items used. A converted 24-ft commercial fishing boat powered by a 180-hp inboard engine towed the trawl.

Otter Trawling Areas

After extensive exploratory trawling, two areas, Agate Bay and the south end of the lake (hereafter termed South Tahoe), were selected as suitable otter trawling sites. The bottom at these locations was relatively flat and free of obstruction, facilitating contour trawling and decreasing the chances of fouling and tearing the net.

The Agate Bay trawling area was located on a large, gently-sloping shelf midway between Flick and Stateline Points. (For a map of Lake Tahoe see Weidlein, Cordone, and Frantz, 1965.) Here, the depth contours were located nearly parallel and adjacent to one another. The substrate, as surmised from materials picked up in the trawl and adhering to the doors, graded from sand and rubble at 100 and 150 ft to mud and clay at 400 and 500 ft. Substantial amounts of vegetation, including *Chara*, filamentous algae, mosses, and liverworts, were trawled from depths of 200 to 350 ft, with lesser amounts from 100, 150, and 400 ft. No plants were taken from 500 ft. Frantz and Cordone (1967) describe these deepwater plant beds in greater detail.

At South Tahoe, the conditions differed somewhat from those at Agate Bay. The trawling contours were staggered and farther removed from one another. The 100-ft contour was located northwest of the mouth of Taylor Creek, off Baldwin Beach. The 200- and 300-ft contours were located several miles to the east, off the Upper Truckee River marsh. The 400-ft trawling contour was initially located off the mouth

[3] Neither was actually gilled; both had been rolled up in the net, presumably as it was dragged along the bottom during retrieval.

of Taylor Creek, but was moved several miles to the east midway through the sampling program. The bottom types found at South Tahoe were similar to those observed at Agate Bay, except that only sand was encountered at the 100-ft depth. The vegetation, although qualitatively similar to that in Agate Bay, was taken in smaller amounts and appeared to be more uniformly distributed with depth. Also, the bottom topography was generally steeper and less uniform than in Agate Bay. As a result, contour trawling at South Tahoe was considerably more difficult.

Night Versus Day Trawling

The relative efficiency of night versus day trawling was determined by comparing the catches of 23 matched pairs of night and day otter trawls. These trawls were made over a period of 4 months (i.e., September 1963 through December 1963) at depths from 100 to 400 ft at both Agate Bay and South Tahoe. In all instances, night catches of sculpins exceeded those made during the day (Table 1). Night trawls caught 95.8% of the total catch of the paired trawls, with values of individual pairs ranging from 66.7% to 100%. The differences in the catch rates were tested statistically using a method for paired observations (Li, 1957; p. 96) and were found to be highly significant ($t = 10.49$, 22 d.f.; $t_{.01} = 2.82$). The data were normalized using a log $(y + 1)$ transformation. Similar tests on tui chub and Tahoe sucker (*Catostomus tahoensis*) catch rates also indicated significant differences between night and day trawls. Night trawls also took 94.5% of the total tui chub catch of the pairs ($t = 6.10$, 9 d.f.; $t_{.01} = 3.25$), and 96.7% of the Tahoe suckers ($t = 3.58$, 13 d.f.; $t_{.01} = 3.01$). No tests were made for the other fish species captured because of insufficient sample sizes.

These data were the basis for the termination of day trawling in December 1963.

Trawling Procedures

From September 1963 through September 1964, one series of night trawls was usually made each month in each of the two trawling areas previously described. However, inclement weather or boat breakdowns prevented trawling at South Tahoe in November 1963 and in both areas in July 1964. Substitute trawls were made the last day in July and early in August for those missed earlier in July. (To avoid confusion, these substitute trawls will hereafter be considered July trawls.) The regular August trawls were made as usual, but nearer the end of the month.

Trawling contours in both areas were located at 100-ft depth intervals between 100 and 400 ft. In addition, supplementary trawls were made at depths of 150, 250, and 350 ft in Agate Bay because of the large horizontal distances between adjacent trawling contours. From June through September 1964, after the installation of a larger capacity winch aboard the boat, trawls were also made in Agate Bay at a depth of 500 ft.

Tows were generally 10 min long, but a few were of shorter duration. Catch rates of the latter were expanded for comparison with the 10-min tows. Similarly, catch rates were combined and averaged for comparison with the standard 10-min tow in those few instances when two or more companion trawls were made in the same location in one

month. The trawl net was towed at an engine speed of approximately 1,100 rpm, giving the boat a speed of about 1½ ft per second (slightly less than one knot). The linear distance covered during a 10-min tow was approximately 900 ft.

Three operational changes were required during the sampling year. Trawls at 100 ft in Agate Bay were discontinued in November because of frequent fouling on rocky obstructions. Trawls in 150 ft were reduced to 5 min in April for the same reason. Even so, these trawls fouled frequently, resulting in extreme variations in catch rates. Fouling also occurred occasionally at other depths in Agate Bay, and at South Tahoe as well. Unfortunately, some of these trawls were not rerun because the extent of the fouling was not considered serious at the time. However, during data analysis a number of these trawls were discarded when it became obvious that serious fouling had occurred. Lastly, in June the 400-ft trawling contour at South Tahoe was relocated to an area where the bottom topography was less variable.

DISTRIBUTION

Spatial Distribution

The Piute sculpin appears to be widely distributed in Tahoe, having been collected from numerous locations around the lake, and from a wide range of depths. From September 1963 through September 1964, 5,471 were taken by otter trawl at Agate Bay and South Tahoe at depths ranging from 100 to 500 ft. Also, substantial numbers of sculpins were taken at depths of 15 to 300 ft during exploratory otter trawling in a variety of lake areas. Large numbers were also taken with rotenone and the sled trawl in shallow water at a number of locations, in some cases at depths less than 5 ft.

Sculpins also occasionally range into extremely deep water. A single specimen was captured in a bottom gill net at a depth of 700 ft, the greatest recorded depth for this species.

The numerical distribution of sculpins in Tahoe appears to be very heterogeneous, reflecting the variety of lake environments and their compatibility with the sculpin. In Agate Bay the mean catch per trawl at the 200-ft depth was 129.2 sculpins, compared with 27.5 for the same depth at South Tahoe (Table 1). Conversely, in 400 ft the mean catch per trawl at Agate Bay was only 19.8, compared with 51.5 at South Tahoe. The mean catch rate in 300 ft at Agate Bay, however, was nearly identical with that at South Tahoe; i.e., 12.2 and 12.4 sculpins, respectively. These differences were tested using analysis of variance procedures, and were found to be highly significant for 200 ft ($F = 54.87^{**}$, $F_{.01} = 9.65$), significant for 400 ft ($F = 8.68^{*}$, $F_{.05} = 4.84$), and not significant for 300 ft ($F = 0.52$, $F_{.05} = 4.84$). The data were normalized using a log $(y + 1)$ transformation, and the degrees of freedom were 1 and 11.

Despite this variability, the largest densities of sculpins generally occurred at depths of 200 ft or less in both trawling areas (Figure 1, Table 1). At South Tahoe, monthly catches in 100 ft varied between 12 and 315 sculpins per trawl, and were generally larger than those for other depths in that area. In 200 ft at Agate Bay, monthly catches ranged from 32 to 244 sculpins per trawl, and were consistently larger

than those from deeper depths. Moreover, data from trawls in 100 and 150 ft in Agate Bay, although incomplete and quite variable due to fouling of the net, indicated even larger densities of sculpins than at 200 ft.

TABLE 1

Otter Trawl Catch Rates of Lake Tahoe Piute Sculpins, September 1963 Through September 1964

Month	Location	Number per 10-min trawl[1]							
		100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	500 ft
September	Agate Bay	--	--	32 (1)	--	4 (0)	--	122 (0)	--
	South Tahoe	--	--	2 (0)	--	5 (0)	--	49 (3)	--
October	Agate Bay	122 (0)	--	98 (0)	--	57 (1)	--	92 (2)	--
	South Tahoe	106 (1)	--	4 (0)	--	10 (0)	--	10 (5)	--
November	Agate Bay	--	4	93 (1)	24	7 (0)	--	33 (1)	--
	South Tahoe	--	--	--	--	--	--	--	--
December	Agate Bay	--	10	197 (18)	17 (2)	11	27	16	--
	South Tahoe	66 (12)	--	13 (3)	--	15 (1)	--	12 (1)	--
January	Agate Bay	--	378	214	76	10	21	8	--
	South Tahoe	12	--	74	--	14	--	117	--
February	Agate Bay	--	--	130	22	5	20	4	--
	South Tahoe	33	--	20	--	5	--	63	--
March	Agate Bay	--	--	146	38	10	26	0	--
	South Tahoe	26	--	60	--	11	--	101	--
April	Agate Bay	--	--	147	42	13	29	14	--
	South Tahoe	44	--	19	--	5	--	89	--
May	Agate Bay	--	154	137	20	6	6	1	--
	South Tahoe	125	--	19	--	20	--	79	--
June	Agate Bay	--	6	132	30	0	19	1	1
	South Tahoe	103	--	26	--	24	--	14	--
July	Agate Bay	--	190	111	61	2	6	1	0
	South Tahoe	65	--	17	--	4	--	4	--
August	Agate Bay	--	2	37	18	8	18	2	0
	South Tahoe	315	--	41	--	9	--	10	--
September	Agate Bay	--	4	123	26	30	16	10	1
	South Tahoe	202	--	18	--	33	--	26	--
Mean[2]	**Agate Bay**	**122.0**	**93.5**	**129.2**	**34.0**	**12.2**	**18.8**	**19.8**	**0.5**
	South Tahoe	**99.7**	---	**27.5**	---	**12.4**	---	**51.5**	---

[1] Day trawl catch rates are shown in parentheses; all others are from night trawls.
[2] The September catch rates are averaged to give equal weight to all months.

The major difference between the two distribution patterns was the exceptionally large catches in 400 ft at South Tahoe during the winter and early spring, which contrasts with the uniformly low catches at this depth throughout most of the year at Agate Bay. These large catches may be manifestations of a seasonal migration into deep water. However, the simultaneous drop in catch with relocation of the trawling contour in June suggests that there are density differences between the two locations. Related to this is the possibility that sculpins may be more abundant on steeper slopes, which would account for the higher catches at the original location. The atypically high catches from September through November in Agate Bay at 400 ft may also be the result of initial adjustments in the trawling locations.

An anomaly in the depth distribution pattern for Agate Bay sculpins was the apparent decrease in densities at 300 ft, relative to adjacent trawling depths. The mean monthly catch for this depth was 12.2 sculpins per trawl, compared with 34.0 and 18.8 for depths of 250 and 350 ft, respectively. It is believed that the plant beds, which are especially abundant at this depth, reduced the efficiency of the trawl. A mean of 35 lb of vegetation (range: 7 to 94) was taken with

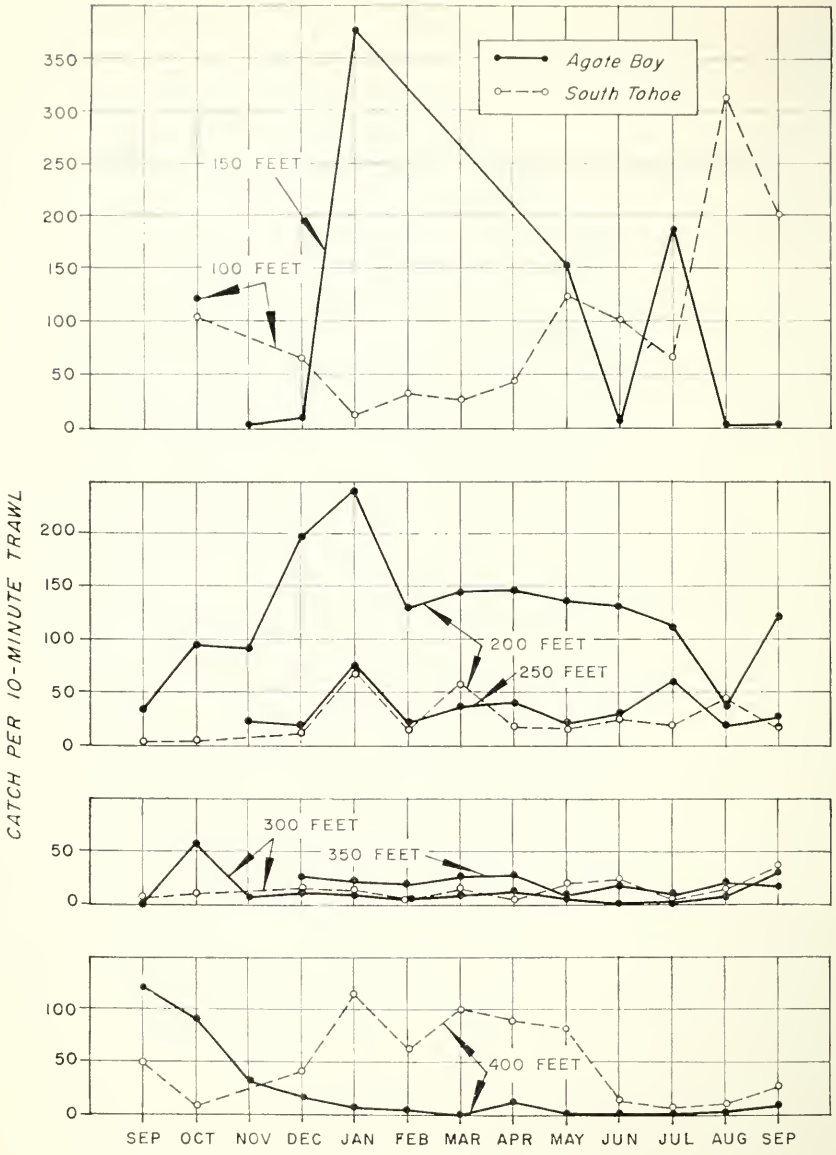


FIGURE 1—Night otter trawl catch rates of Lake Tahoe Piute sculpins, by area, September 1963 through September 1964.

the trawl during 10-min tows at this depth, excluding plants caught around the mouth of the trawl and on the otter doors. Since significant amounts of vegetation also occur at 250 and 350 ft (means of 8 and 24 lb, respectively), catches in these depths may likewise be slightly depressed.

Seasonal Distribution

Although sculpin catches for given depths changed throughout the year, there were no definite indications of seasonal or spawning migrations. Moreover, these changes were not consistent between areas. According to Miller (1951) and Ebert and Summerfelt (1969), spawning occurs from early May to late August in shallow rocky areas. We could find no evidence that sculpins spawned in the 100- to 500-ft

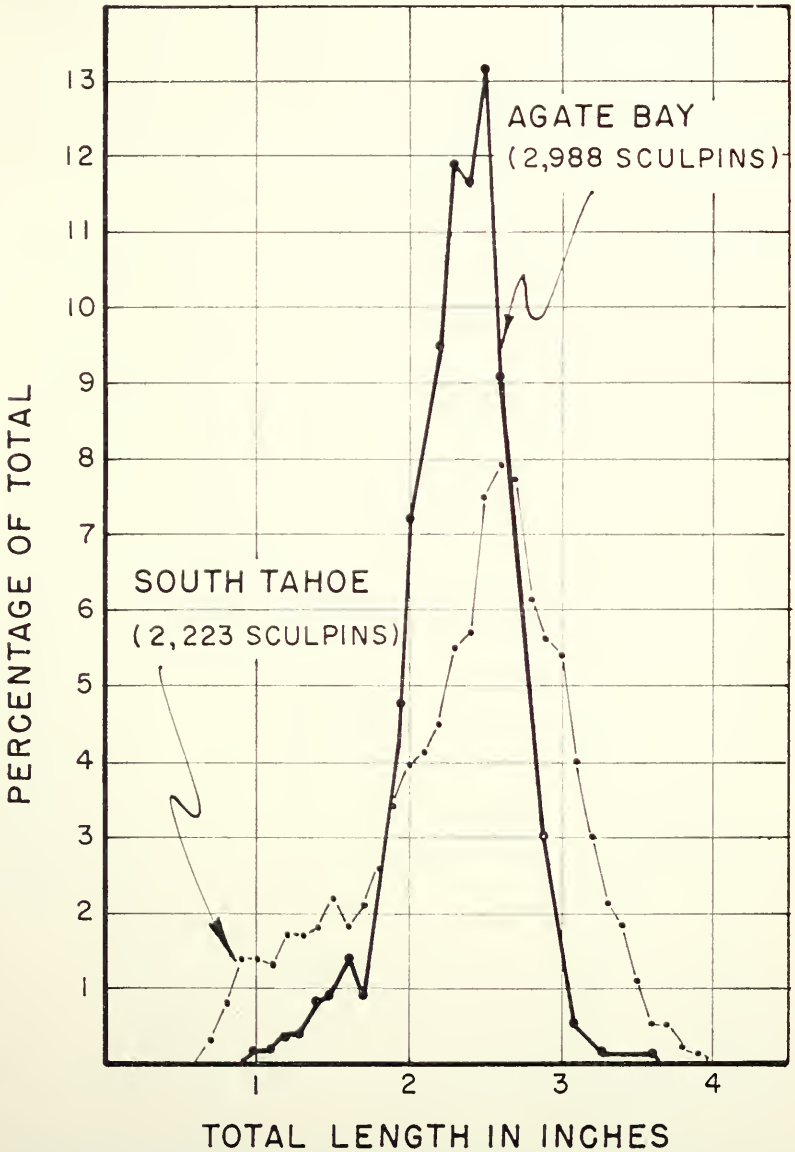


FIGURE 2—Length frequencies of Lake Tahoe Piute sculpins taken during night otter trawling at Agate Bay and South Tahoe from October 1963 through September 1964.

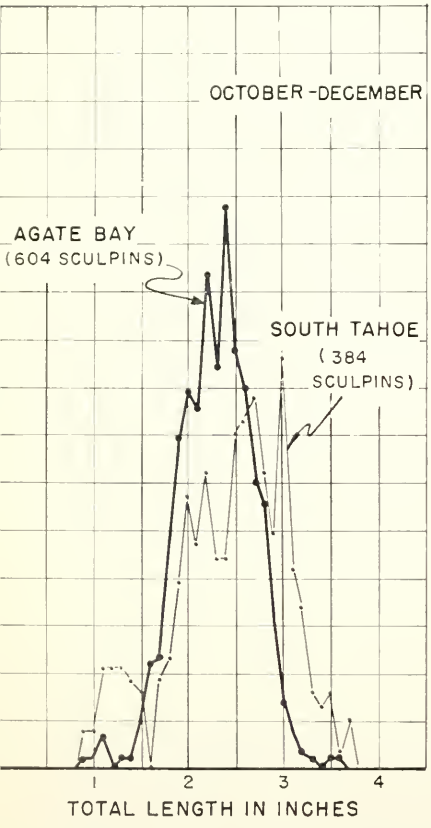
trawling zone. The trawl catches also did not demonstrate a spring migration into shallow water. Sampling variability and the difficulties of trawling in depths under 100 ft probably prevented detection of such movements.

SIZE COMPOSITION

The size of sculpins sampled during otter trawling operations from October 1963 through September 1964 ranged from 0.7 to 5.0 inches TL. However, only 3 of the 5,200 measured were 4.0 inches or longer. The mean length of sculpins from both areas and all depths was 2.37 inches. The largest sculpin reported by Miller (1951) was 4.9 inches TL.

The mean length of sculpins sampled at depths of 200, 300, and 400 ft in Agate Bay was 2.33 inches, compared with 2.44 inches for the same depths at South Tahoe. This difference, although small, was found to be highly significant when tested statistically by analysis of variance ($F = 160.16^{**}$, d.f. $= 1, 2817$, $F_{.01} = 6.64$).

The size composition of sculpins sampled in the two areas was also quite dissimilar, suggesting that little, if any, intermingling occurs



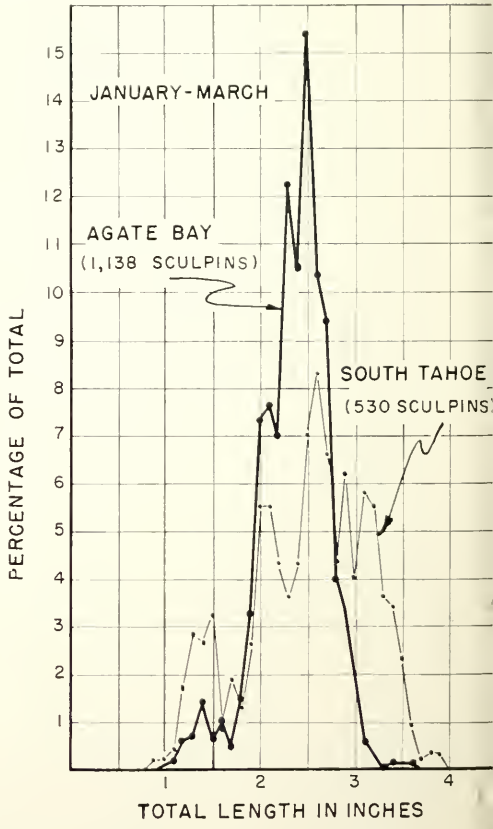


FIGURE 3—Length frequencies by season of Lake Tahoe Piute sculpins taken during night otter trawling at Agate Bay and South Tahoe from October 1963 through March 1964.

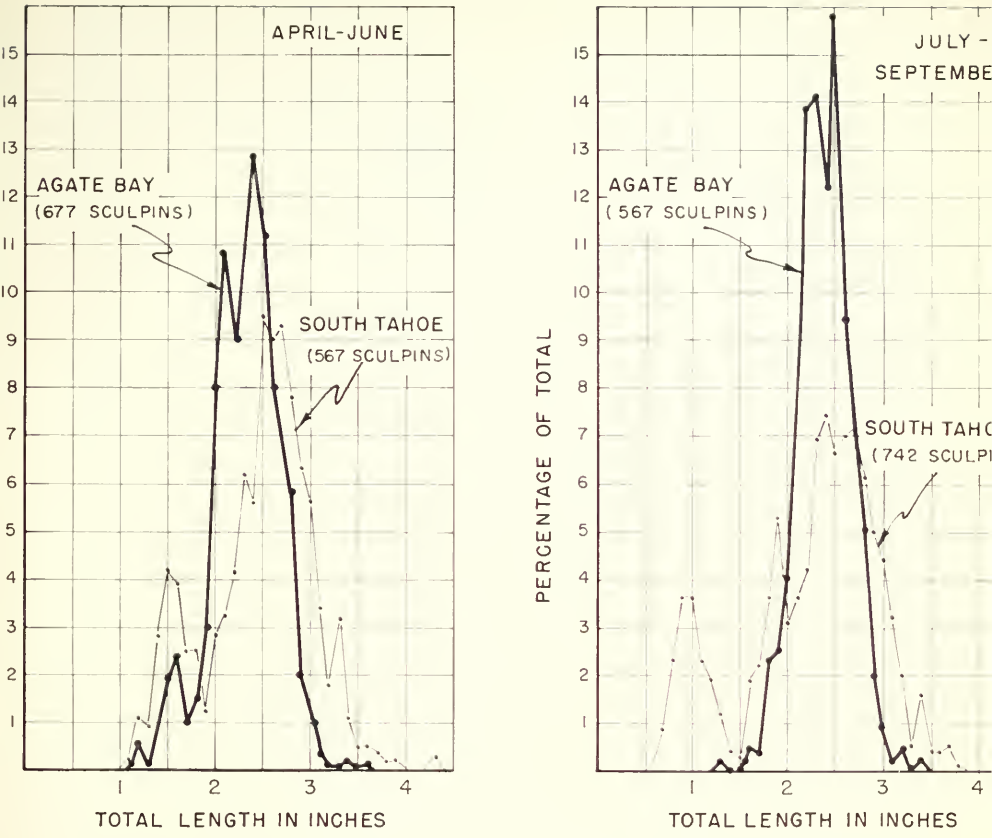


FIGURE 4—Length frequencies by season of Lake Tahoe Piute sculpins taken during night otter trawling at Agate Bay and South Tahoe from April 1964 through September 1964.

between these populations. Proportionately, more large and small sculpins were sampled at South Tahoe (Figure 2). For example, 13.5% of the sculpins sampled at South Tahoe were larger than 3.0 inches, while only 1.3% of the Agate Bay samples were in this range. In addition, 22.4% of the sculpins from South Tahoe were smaller than 2.0 inches, compared with 11.2% from Agate Bay. The variances of the two distributions were compared statistically with the F-test, and the difference was highly significant ($F = 3.25^{**}$, d.f. = 2222, 2987; $F_{.01} = 1.00$). Area differences in year-class strength are probably responsible. In Agate Bay, it appears that the 1963 and 1964 year classes were weak compared with those sampled at South Tahoe (Figures 3 and 4). However, in Agate Bay the 1962 year class, and possibly one or two earlier year classes, were strong. Samples taken at Agate Bay in November 1962, during exploratory otter trawling, revealed a strong 1962 year class in the 0.8- to 1.5-inch size range (Figure 5). This length frequency distribution was similar to that sampled at South Tahoe during the fall of 1964 but, here again, the older year classes appeared weak.

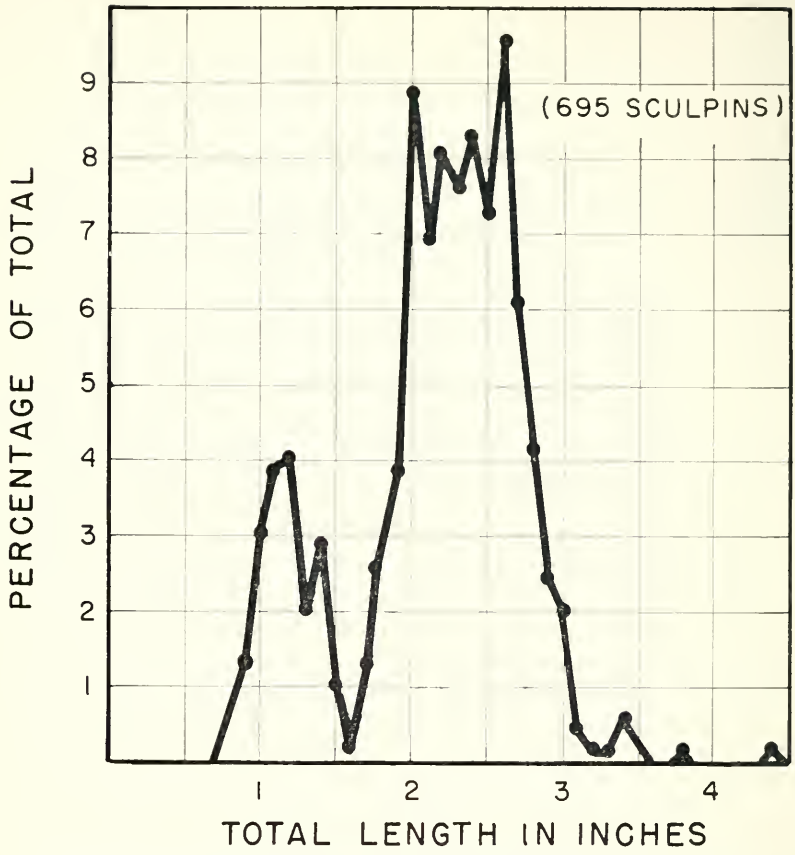


FIGURE 5—Length frequency of Lake Tahoe Piute sculpins taken during exploratory trawling at Agate Bay in November 1962.

Length frequency distributions also indicate that proportionately larger number of small sculpins are found in shallow water. The largest percentage of small sculpins sampled by otter trawl was taken at South Tahoe in 100 ft. Over 28% were less than 2.0 inches long. Moreover, 39.2% of the sculpins sampled by rotenone were in this size range. Finally, some very small sculpins were taken in September 1963 (0.8 to 1.1 inches), July 1964 (0.3 to 0.7 inch), and August 1965 (0.5 to 0.8 inch) by sled trawl at depths of 10 to 50 ft. These collections may reflect the dispersal of young-of-the-year sculpins from the rocky nearshore areas. Miller (1951) and Ebert and Summerfelt (1969) both observed incubating sculpin eggs in water less than 4 ft deep.

RELATIVE ABUNDANCE

Like most other sampling methods, otter trawling is selective, capturing an unknown segment of the fish population in its path. The fraction taken undoubtedly does not provide an index of true species abundance and composition. However, for certain species the indices

TABLE 2

Species Composition of Otter Trawl Catches in Lake Tahoe, September 1963 Through September 1964 [1]

Species	Location	100 ft		150 ft		200 ft		250 ft		300 ft		350 ft		400 ft		500 ft		Totals	
		No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Lake trout	Agate Bay	0	0.0	1	0.1	6	0.1	4	0.1	0	0.0	1	0.5	2	0.8	0	0.0	14	0.2
	South Tahoe	8	0.3	--	--	2	0.1	--	--	5	2.7	--	--	2	0.3	--	--	17	0.3
Mountain whitefish	Agate Bay	4	1.2	1	0.1	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	6	0.1
	South Tahoe	2	0.1	--	--	0	0.0	--	--	0	0.0	--	--	0	0.0	--	--	2	0.0
Tahoe sucker	Agate Bay	26	7.8	59	5.2	43	0.9	27	2.9	6	2.9	2	1.0	2	0.8	0	0.0	165	2.2
	South Tahoe	90	3.3	--	--	88	5.9	--	--	42	22.8	--	--	6	1.0	--	--	226	4.6
Tui chub	Agate Bay	182	51.5	334	29.2	3,006	65.3	530	56.7	55	26.6	2	1.0	1	0.4	0	0.0	4,110	53.6
	South Tahoe	1,498	55.5	--	--	1,096	73.4	--	--	1	0.5	--	--	1	0.2	--	--	2,596	52.4
Lahonton speckled dace	Agate Bay	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	South Tahoe	5	0.2	--	--	4	0.3	--	--	0	0.0	--	--	0	0.0	--	--	9	0.2
Piute sculpin	Agate Bay	122	36.5	748	65.4	1,550	33.7	374	40.0	146	70.5	188	97.4	238	97.9	2	100.0	3,368	41.0
	South Tahoe	1,097	40.6	--	--	303	20.3	--	--	136	73.9	--	--	567	98.4	--	--	2,103	42.5
Total	**Agate Bay**	**334**	100.0	**1,143**	100.0	**4,606**	100.0	**935**	100.0	**207**	100.0	**193**	99.9	**243**	99.9	**2**	100.0	**7,663**	100.1
	South Tahoe	**2,700**	100.0	--	--	**1,493**	100.0	--	--	184	99.9	--	--	**576**	99.9	--	--	**4,953**	100.0

[1] Based on night trawl catch rates only. The September catch rates are averaged to give equal weight to all months.

obtained may be sufficiently accurate so that substantial changes in the fish population would be detectable by duplicating the sampling scheme and using the same methods and materials.

The otter trawl collections provide an index of species composition and relative densities for both Piute sculpin and tui chub taken in the 100- to 500-ft zone (Table 2). These species were taken in much greater numbers than the remaining species: mountain whitefish (*Coregonus williamsoni*), lake trout (*Salvelinus namaycush*), Tahoe sucker, and Lahontan speckled dace (*Rhinichthys osculus robustus*). Many factors could be responsible for the low numbers of these species. The dominance of chubs and sculpins appears real, however, since minnow trapping and gill netting in this area uncovered no unusual concentrations of the other species.

In the 100- to 500-ft zone, chubs were the most abundant species, comprising about 53% of the total, followed by sculpins at 43%, and suckers at 3%. The remaining species each comprised less than 0.3% of the total. Relative densities of chubs and sculpins may be biased because sculpins tend to move more slowly and are more closely associated with the substrate than chubs. Nevertheless, sculpins are clearly more abundant than chubs in water deeper than 300 ft, while the reverse is true for depths less than 300 ft.

Sculpins also appear to be important in the shallow littoral zone of Lake Tahoe. Baker (1967) noted that sculpins comprised about 7% of the fishes taken in shoreline rotenone collections, and about 32% of the sled trawl collections taken in the 10- to 50-ft depth zone.

DISCUSSION

Miller (1951) mentioned the distribution of Piute sculpin in Lake Tahoe: "The freshwater sculpin, *Cottus beldingii*, inhabits the littoral slopes of Lake Tahoe where gravels and boulders provide it some shelter. While it is frequently seen among the rocks in extreme and moderate shallows, the fact that it occurs in 50% of the mackinaw trout stomachs leads to the assertion that this fish abounds at great depths." Shoreline rotenone and sled trawl sampling confirmed their presence in the littoral zone, and otter trawling demonstrated their presence at depths to 400 ft. Only two were caught, however, at 500 ft and one (in a gill net) at 700 ft. It appears that sculpin numbers decline appreciably at depths approaching 400 ft and apparently few invade the profundal zone of Lake Tahoe.

According to the otter trawl samples and other information, greatest sculpin concentrations occur in boulder and rubble areas. It was not possible to sample specifically the steep slopes in Tahoe; however, the evidence suggests that they occur here in large numbers also.

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E. Marshall, and Charles C. Young, Jr. designed and constructed the power gear used to handle the collecting equipment aboard the research boat. Harold K. Chadwick helped with statistical analysis of the data. Alex J. Calhoun and Robert F. Elwell helped in the planning and editing of this report. The following provided berthing for our research boat and other services to the project: John B. DeMaria, Obexer's Boat and Motor Sales, Tahoe Boat Company, Sierra Boat Company, Logan Shoals Marina, Lakeside Marina, and the California Department of Parks and Recreation. To these, and to others not mentioned who have contributed to the study, we offer our sincere thanks.

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CALIFORNIA CONDOR SURVEYS, 1968[1]

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The fourth annual California condor (*Gymnogyps californianus*) survey was conducted October 16 and 17, 1968. Seventy-seven sightings were reported from 18 of 66 stations manned on October 16, 1968. One hundred seventy-four sightings were reported from 20 of 66 stations manned on October 17, 1968. These sightings, by an evaluation of field reports, were reduced to minimum counts of 33 and 52 individual birds, respectively, for the 2-day survey. The evaluation procedures have been the same for all four annual surveys. The results are considered minimum population counts. At least seven young birds were reported in this year's survey.

An experimental baiting program utilizing deer carcasses was conducted to determine its usefulness as an alternate survey method to the annual condor survey. The first baiting survey was conducted May 6–8, 1968. During this time condors were observed at three of the six bait stations, with eight sightings reported. On the second baiting survey October 22–24, 1968, condors were observed at five of the stations manned during the 3-day period, with 154 sightings reported. Thirty-two individual birds were seen on October 24. Prebaiting and bait location were very important in producing bait acceptance. Care was taken to select bait stations which insured the safety of condors while they were at the bait station.

INTRODUCTION

Cooperative California condor surveys have been conducted annually in October since 1965. The Fourth Annual California Condor Survey was conducted October 16–17, 1968. Survey procedures are coordinated by a Condor Survey Committee representing the California Department of Fish and Game, U. S. Fish and Wildlife Service, U. S. Forest Service, National Audubon Society, University of California, and other conservation interests.

As the annual surveys were reviewed, the Condor Survey Committee recognized the need to investigate alternative survey methods. It was suggested that an experimental baiting survey be conducted in addition to the regular annual survey. Condors have been baited with varying degrees of success and it was hoped this would provide another census method.

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[2] Prepared for and with approval of the Condor Survey Committee: Chairman Ben Glading, former Chief of Wildlife Management Branch, California Department of Fish and Game; A. Starker Leopold, Professor of Zoology, University of California; William P. Dasmann, U. S. Forest Service; Clinton H. Lostetter, U. S. Fish and Wildlife Service; John C. Borneman, National Audubon Society; Fred C. Sibley, U. S. Fish and Wildlife Service; and Robert D. Mallette, California Department of Fish and Game.

In 1968, the Condor Survey Committee authorized studies to determine the feasibility of baiting as a reliable survey method. Objectives of the baiting survey are similar to those for the annual survey: (i) establish periodic condor population counts to detect population trends, (ii) gain an indication of the young birds entering the population, based on the age classification of birds observed, (iii) obtain more information on the distribution of condors, (iv) foster public awareness of the precarious status of the species and problems related to its protection, and (v) gain other knowledge of condors and raptors as incidentally provided by such survey.

The first experimental baiting survey was conducted on May 6–8, 1968; a second baiting survey was conducted on October 22–24, 1968, to compare results with those obtained during the annual survey on October 16 and 17, 1968.

METHODS

Annual Survey

The survey methods and evaluation procedures were essentially the same as reported for the 1965–67 surveys (Mallette and Borneman, 1966; Mallette et al., 1967; Sibley et al., 1968). Operational changes in the 1968 survey involved minor shifts in station locations. Two stations were eliminated because of inaccessibility. Three additional stations were established in Kern County to aid in the evaluation of condor movements in areas where there is a concentration of birds.

Baiting Surveys

Based on prior knowledge of condor distribution, six bait stations were selected in key locations of the condor range. On the May baiting survey, stations were located at: (1) Salisbury Potrero, Santa Barbara County; (2) Snedden Ranch, Kern County; (3) Bald Mountain, Ventura County; (4) Tejon Ranch, Kern County; (5) Ellsworth Ranch, Kern County; (6) Grouse Valley, Tulare County. Stations 3, 4, and 5 were shifted 1 to 2 miles for the October baiting survey and station 6 at Grouse Valley, Tulare County, was moved to the Tejon Ranch, Kern County. This made two stations on the Tejon Ranch. Station 5, on the Ellsworth Ranch, was prebaited but was not operated because an automobile accident prevented observers from manning the station on the October baiting survey.

"Road-kill" deer carcasses were used for condor bait. Deer was considered the preferred food, based on reports of earlier authorities. Preliminary baiting indicated that stations prebaited 1 week before the survey would increase the chance of birds finding the bait. Some baiting sites appeared to be unacceptable to condors, although carcasses placed a mile away were quickly consumed. Stations were selected in isolated protected areas to minimize possible harm to condors while they were in the vicinity of the bait station.

Sites were chosen where two-man observer teams could maintain close surveillance from good vantage points $\frac{1}{2}$ to $\frac{3}{4}$ mile from the bait station. Observers manned the observation stations from approximately 8 a.m. to 5 p.m. each day and recorded all observations of condors and other raptors feeding on the bait or in the general area. A second deer carcass was placed at each baiting station early the 1st day of the 3-day survey, thus insuring an adequate food supply for birds in the area. Each

observer was equipped with binoculars of 7 power or greater, and each observation station was equipped with a 20x spotting scope.

WEATHER

Annual Survey

The weather on both days of the annual survey was generally fair and warm, with easterly winds of 4 to 18 mph prevailing over much of the area (Table 1). Some stations reported strong winds with gusts up to 50 to 60 mph at times during both days of the survey. Before the survey, an inch of rain fell in southern portions of the condor range. This made road conditions difficult in some areas and necessitated relocation of two stations. However, weather during the survey provided good soaring or flying conditions for condors.

Baiting Surveys

The weather during both baiting surveys was favorable for condor flight. Winds varied from 5 to 15 mph and temperatures were normal

TABLE 1

U. S. Forest Service Lookout Stations Reporting Weather Information *

(Readings Were Taken at 2 p.m. on October 16 and 17, 1968)

Lookout station	County	Average wind velocity (mph)		Direction of wind (from)		Temperature (F)		Relative humidity	
		16	17	16	17	16	17	16	17
Thorn Point	Ventura	10	8	NE	NW	52	58	24	16
Nordhoff	Ventura	4	4	SE	SE	69	71	26	25
McPherson	Santa Barbara	6	6	NE	NE	53	60	61	39
Figueroa	Santa Barbara	6	4	W	SW	72	76	24	17
Hi Mountain	San Luis Obispo	18	12	NE	NE	65	75	50	27

* Lookout stations were also condor survey stations.

TABLE 2

U. S. Forest Service Lookout Stations Reporting Weather Information In Baiting Survey Area

(Readings Were Taken at 2 p.m. on October 22–24, 1968)

Lookout station	County	Average wind velocity (mph)			Direction of wind (from)			Temperature (F)			Relative humidity		
		22	23	24	22	23	24	22	23	24	22	23	24
Thorn Point	Ventura	6	8	6	S	SE	SE	70	70	75	12	12	10
Nordhoff	Ventura	8	8	8	SE	E	SW	77	80	79	19	15	19
McPherson	Santa Barbara	8	8	8	SW	S	SW	70	75	76	15	10	13
Figueroa	Santa Barbara	6	6	6	*	SW	SW	80	84	87	18	10	9

* Data not available.

for the two survey periods. Weather had no known adverse influence on condor movement preceding or during the surveys. Table 2 presents weather data for the October 22–24 baiting survey. Data were not available for the May 6–8 baiting survey.

RESULTS

Annual Survey

On October 16, 66 stations were manned by 137 observers and 77 condor sightings were reported from 18 stations (Figure 1). The evaluation of these reported sightings reduced the individual condor count to 33. The age classification breakdown was 18 adults, 5 young (1 subadult, 2 immatures, 2 juveniles), and 10 unknown. The observers also reported 1,553 other raptors, of 15 species (Table 3).

On October 17 the same 66 stations were manned by 136 observers and 174 condor sightings were reported from 20 stations. By an evaluation of these sightings, 52 individual condors were seen. The age classification breakdown was 43 adults, 5 young (1 immature, 4 juveniles), and 4 unknown. A total of 2,671 other raptors of 15 species (Table 3) were recorded.

TABLE 3

Raptor Sightings Reported During Annual Condor Survey October 16–17, 1968 *

Species	Date reported		Species	Date reported	
	Oct. 16	Oct. 17		Oct. 16	Oct. 17
Turkey vulture, *Cathartes aura*	975	2,115	Ferruginous hawk, *Buteo regalis*	2	2
Golden eagle, *Aquila chrysaetos*	113	127	Red-shouldered hawk, *Buteo lineatus*	2	1
Bald eagle, *Haliaeetus leucocephalus*	1	1	Pigeon hawk, *Falco columbarius*	3	1
Goshawk, *Accipiter gentilis*	1	0	Sparrow hawk, *Falco sparverius*	55	49
Sharp-shinned hawk, *Accipiter striatus*	31	29	Prairie falcon, *Falco mexicanus*	4	2
Cooper's hawk, *Accipiter cooperii*	40	36	Peregrine falcon, *Falco peregrinus*	0	1
Red-tailed hawk, *Buteo jamaicensis*	275	255	White-tailed kite, *Elanus leucurus*	0	2
Swainson's hawk, *Buteo swainsoni*	4	6	Marsh hawk, *Circus cyaneus*	8	1
Rough-legged hawk, *Buteo lagopus*	3	0	Miscellaneous raptors	36	43
			Totals	1,553	2,671

* These sightings were not subjected to the same evaluation process as condor sightings.

Baiting Surveys

The first experimental condor baiting survey was conducted on May 6–8, 1968. Condors were observed at three of the six bait stations, with a total of eight sightings (Table 4).

The baiting failed to concentrate condors at the bait stations or to hold birds for extended periods, as was hoped. Condors fed at station 1 only, and this was the only location where condors remained for more than a few minutes. Based on these results, several changes in bait location were made for the second baiting survey.

Bait acceptance by condors was very poor during the first experimental baiting survey. Evidently this was due to an abundance of other food and the improper location of some bait stations. At some stations no scavenger species fed. At three stations, the bait was moved a short distance and/or additional bait added during the survey to correct imagined or real flaws in the location of the bait. None of these moves produced acceptance by the condors.

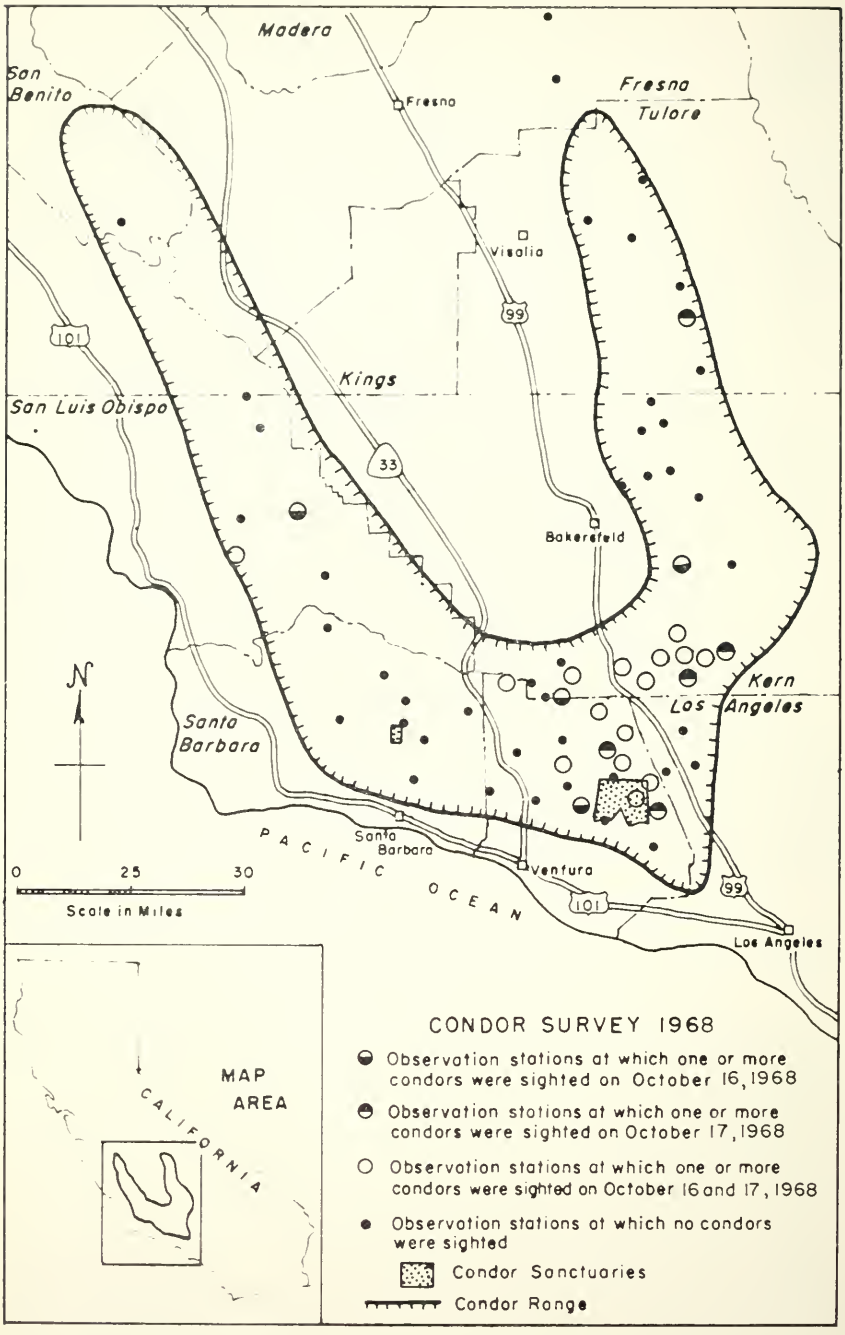

FIGURE 1—Locations of condor survey observation stations and sightings on October 16 and 17, 1968. *Drawing by Cliffa Corson.*

TABLE 4

Results of Condor Baiting Survey
May 6–8, 1968

Station	County	Individual condors seen		
		May 6	May 7	May 8
1 Salisbury Potrero	Santa Barbara	0	0	2 adults*
2 Snedden Ranch	Kern	0	0	0
3 Bald Mountain	Ventura	1 adult 1 unknown	1 adult	1 adult
4 Tejon Ranch	Kern	0	0	0
5 Ellsworth Ranch	Kern	0	0	1 immature 1 unknown
6 Grouse Valley	Tulare	0	0	0
Total		2	1	5

* Denotes birds observed feeding on bait.

At station 6, two to seven turkey vultures passed over the bait each day, but headed for some other destination. A similar behavior pattern was noted for four condors at station 3. At station 5, one immature condor came over and inspected the observers but did not inspect the bait. At station 3, observations were continued after the baiting survey and on May 9 one bird fed momentarily before being flushed off by a sonic boom. On May 10, ten sightings were made of seven condors over the bait area, but none of these birds deviated from its glide path to inspect the bait.

The second condor baiting survey was conducted on October 22–24, 1968 (Figure 2). Condors fed at four bait stations and 32 individual condors were seen at five stations on October 24 (Table 5). Twenty-six condors were observed at station 4 in southern Kern County in the same area where 22 condors were reported during the condor survey a week earlier.

Bait acceptance was good on the second experimental baiting survey. This was thought to be due to placement of bait in areas where condors had been observed the week before and at proven feeding sites. With prebaiting a week prior to the survey it was still the 3rd day of the survey before condors came in any numbers to feed on the bait carcass. Observers at station 4 noted that a number of condors passing near the bait had full crops on the 2nd day of the survey and it was apparent they were feeding on a carcass elsewhere. A longer prebait period may be necessary to allow condors in the area time to accept the bait.

The age of the bait carcass apparently had no influence on its acceptability. Birds readily ate flesh from fresh carcasses as well as those 1 and 2 weeks old.

No correlation was attempted between the baiting and annual surveys. At least another year's data are needed for any meaningful comparisons.

FIGURE 2—California condors observed at a baiting station. On October 24, 1968, 32 birds were observed at five baiting stations. *Photograph by Fred C. Sibley.*

TABLE 5

Results of Condor Baiting Survey
October 22–24, 1968

Station	County	Individual condors seen		
		Oct. 22	Oct. 23	Oct. 24
1 Salisbury Potrero	Santa Barbara	0	2 adults	2 adults*
2 Snedden Ranch	Kern	1 adult	0	1 adult
3 Bald Mountain	Ventura	1 adult*	1 adult* 1 juvenile*	1 adult* 1 juvenile*
4 Tejon Ranch	Kern	3 adults* (1 fed)	9 adults 1 subadult	23 adults* 1 subadult* 2 juvenile*
6 Tejon Ranch	Kern	2 adults 1 juvenile	6 adults	1 adult* 1 unknown
Total		**7 adults** **1 juvenile**	**19 adults** **1 subadult** **2 juveniles**	**28 adults** **1 subadult** **3 juveniles**

Note: An additional adult condor was observed on October 24 between 12:30 and 1:30 p.m. at Hi Mountain, San Luis Obispo County.
* Denotes birds observed feeding on bait.

DISCUSSION

The survey results are not fully comparable with those of previous surveys because of changes in survey effort, station locations, and weather conditions; however, survey observations do not indicate any major changes in the total condor population. Survey reports reveal that five young birds (comprising at least seven individuals) were seen each day of the survey. This is below the 25 to 30% young that Koford (1953) estimated were needed to sustain the condor population.

Molt data from the young condor presently in captivity at the Los Angeles Zoo reveals that prior aging methods may not be reliable. This captive bird was approximately 3 years old in May 1969. It still possesses a color pattern once thought to be that of the juvenile or 1st year age class. This underwing pattern has been used in previous surveys (Mallette et al., 1967) to predict the number of young condors fledged in the previous year. These predictions may not be valid, based on current molting studies on a single captive condor.

Indications are that condors continue to concentrate in southern Kern County in October. A similar distribution pattern was evident in the three previous condor surveys. On October 17, 1968, approximately 63% of the birds observed were east of U. S. Highway 99, 30% were in the area between U. S. Highway 99 and State Highway 33, and 7% were west of State Highway 33 (Figure 1).

RECOMMENDATIONS

Based on four years of condor survey observation reports, and in an effort to minimize survey expenditures without adversely affecting survey results, the following recommendations are made.

1) Approximately 20 nonproductive observation stations should be eliminated from the survey effort in the northern portion of the condor range. Distribution of the major portion of the condor population at this time of year has been determined through previous years' surveys; consequently, elimination of nonproductive stations would not significantly affect the survey results. U. S. Forest Service and California Division of Forestry lookouts in these areas would be retained as observation stations to monitor condor movements.

2) A complete review should be made of the observation station locations and the number of observers needed. In areas of condor concentrations additional stations, minor location changes, and additional observers at key stations would be advantageous in monitoring bird movements.

3) Observer field training sessions should be eliminated for qualified observers. New observers and those needing additional training would attend training sessions on Mt. Pinos, Kern County.

4) All observers participating in the survey should attend the training session the day before the survey to review condor and raptor identification and survey procedures.

5) Baiting surveys should be continued. Baiting techniques and the location of bait stations should be refined, based on the intensive field studies currently being conducted.

ACKNOWLEDGMENTS

The Condor Survey Committee again wishes to thank all of the persons who participated in the condor survey. The return of many observers who participated in earlier surveys increases the reliability of the survey results. The continued cooperation of the National Audubon Society, U. S. Forest Service, U. S. Fish and Wildlife Service, California Department of Fish and Game, California Division of Forestry, Sequoia National Park, and interested ranchers and conservationists is greatly appreciated.

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REDESCRIPTION OF *PARELAPHOSTRONGYLUS* (BOEV AND SCHULS, 1950) IN CALIFORNIA DEER, WITH STUDIES ON ITS LIFE HISTORY AND PATHOLOGY[1]

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The nematode *Elaphostrongylus odocoilei* Hobmaier and Hobmaier (1934) (*Parelaphostrongylus*, Boev and Schuls 1950) is described from recent specimens taken from a black-tailed deer. These are the first specimens since the holotype was described. Measurements and description agree with those of the Hobmaiers, except for the corpus gubernaculi and the dorsal ray of the bursa. These nematodes were in the musculature posterior to the shoulders and in the larger blood vessels of the lung. Parasites from the California mule deer represent a new host record. Deer were experimentally infected with fourth-stage larvae from infected snails and slugs. In heavy infestations extensive tissue damage occurred in lungs and lymph nodes due to granulomatous changes surrounding ova and first-stage larvae. Reference is made to the apparent erroneous original description of the corpus gubernaculi and the variations in the structure of the dorsal ray of the male bursa and its probable implication in the speciation of the parasite.

INTRODUCTION

Hobmaier and Hobmaier (1934) described a lungworm disease of black-tailed deer (*Odocoileus hemionus columbianus*) in California; placed the parasite in the genus *Elaphostrongylus*; and proposed the name *Elaphostrongylus odocoilei* (sp. n.). Since the original description no other specimens of this parasite had been recorded in California. In the course of autopsies of deer by the Wildlife Investigations Laboratory of the California Department of Fish and Game, lungs of deer commonly were found parasitized by the ova and larvae of a nematode. Since these ova and larvae were similar to those described by the Hobmaiers, a careful search was made of the blood vessels and their connective tissues for adult nematodes without success. This was done in a substantial number of cases.

In March 1961 a 12-month-old female black-tailed deer was found in Butte County in a moribund condition and was brought to the laboratory for autopsy. The deer was in poor physical condition but with the exception of the lungs no gross abnormalities or disease were noted. The cut surface of the lung was granular in appearance and when slices of the tissue were examined with the aid of a dissecting microscope innumerable small nodules which contained what appeared to be nematode ova and larvae were seen. Scrapings from the cut surface showed enormous numbers of a very active larval nematode. All

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parts of the lung examined showed the same condition. The primary cause of death was an overwhelming parasitemia of the lungs with ova and larvae indistinguishable from those described for *E. odocoilei*.

Lymph nodes contained masses of ova and a few larvae embolized in dilations of afferent and capsular vessels and in the peripheral sinuses. Those involved included superficial and deep inguinal, aortic, rumenal, tracheal, and bronchial nodes. No ova were present in the lymph nodes of the intestines and mesenteries, nor in those of the axilla, neck, or head. Dissection of the blood vessels and their connective tissues of the spine, intercostal vessels, and those of the major branches of the hind legs was negative. Adult nematodes were present in all of the musculature except the shoulder, neck, and head regions. No nematodes were found in the cranial cavity or the spinal cord.

Dissection was carried out with the use of a dissecting microscope. Small strips of muscle were shredded and separated with small scalpel blades and needles. The muscle was separated with a tearing action, causing the nematode to bridge the separated space. Nematodes were found in several situations. Most of them were in the lumen of lymphatic or capillary blood vessels which wound in a tortuous manner through the tissue, making it extremely difficult to extract entire specimens. Others were coiled in muscle fascia and connective tissue. Males and females were often in close proximity and one female was found with a male partly coiled about the caudal end. No nematodes were associated with the larger blood vessels with the exception of the lung, where six adult females were in the lumen of these vessels. In one case the vessel wall was penetrated and the nematode was partly in the lung parenchyma. In subsequent autopsies occasional hemorrhagic areas were noted in the musculature. These varied from very small areas to others approximately 1.5 cm in diameter and were deep as well as subcutaneous. In these areas one to several nematodes were found. In all autopsies the nematodes were in similiar areas of the animal's musculature; occasionally a mass of ova was found between the muscle fibers.

Lung scrapings taken from California mule deer, *O. h. californicus*, in 58 of 59 samples revealed the presence of ova and larvae which were identical with those described. In 1963 an adult female and a 12-month-old male California mule deer contained adult nematodes in the musculature in the same situations as in the black-tailed deer. These nematodes were identified as *Elaphostrongylus* (*Parelaphostrongylus*) *odocoilei*. This represents a new host record for this species.

DESCRIPTION

These nematodes are long and slender, with a very delicate cuticle. Each end is slightly attenuated and no teguminal sheath is apparent. The anterior end is covered by a thickened cuticular cap roughened on the internal surface (Figure 1). Six reduced lips, each bearing a papilla, are present. Papillae of the external circle are represented by two dorso-laterals and by two ventro-laterals. The oral opening is bordered by a cuticular ring and leads into an infundibuliform symmetrical stoma, the walls of which are selerotized. The dorsal stomatal plate is continuous with the esophageal lining and in the ventral areas the posterior ends of the plates are inserted into the body of the corpora.

FIGURE 1—The anterior end of female *P. odocoilei*, lateral view.
Photograph by William E. Schafer.

The esophagus is muscular and club-shaped. The excretory pore is prominent, with a sclerotized Y-shaped duct which drains two elongated excretory glands. The intestine in fresh specimens varies from bright green to brown and tends to be somewhat tortuous.

The male bursa is simple and symmetrical (Figure 2). Ventral rays are relatively short, originating from a single stem and directed anteriorly; the externo-laterals are separate and longer than the ventrals; the medio- and posterio-laterals originate from a common stem; the externo-dorsal is long and separate. The dorsal ray is mound-like and variable in structure. The various forms are figured (Figure 3). The form described by the Hobmaiers as typical (two stems with two papillae on each) was the least common of the variations.

Spicules are relatively stout, with a capitulum set off from the shaft by a constricted neck. The shaft is slightly curved dorso-ventrally and is uniform in thickness except for the tapered distal extremity. The shaft bears prominent dorsal and ventral pectinate alae. When viewed from a dorso-ventral plane the terminus of the shaft bears an accessory

curved point which forms one side of a spoon-shaped structure; the other side is formed by an extension of the dorsal alae.

The gubernaculum has a corpus and two lateral crura (Figure 4). The corpus is an elongated structure widening anteriorly from the crura and tapering to the anterior end. The posterior third of the body is split; the crura are lateral to the termini of the body and above each is a dome-like projection. The lateral edges of the corpus are thick, becoming thinner at midline. When viewed laterally it has a bow-like structure with pointed ends and appears to be made of longitudinal fibers. Dorso-ventrally it is granular in appearance. The crura are

FIGURE 2—Caudal end of male *P. odocoilei*, lateral view.
Photograph by William E. Schafer.

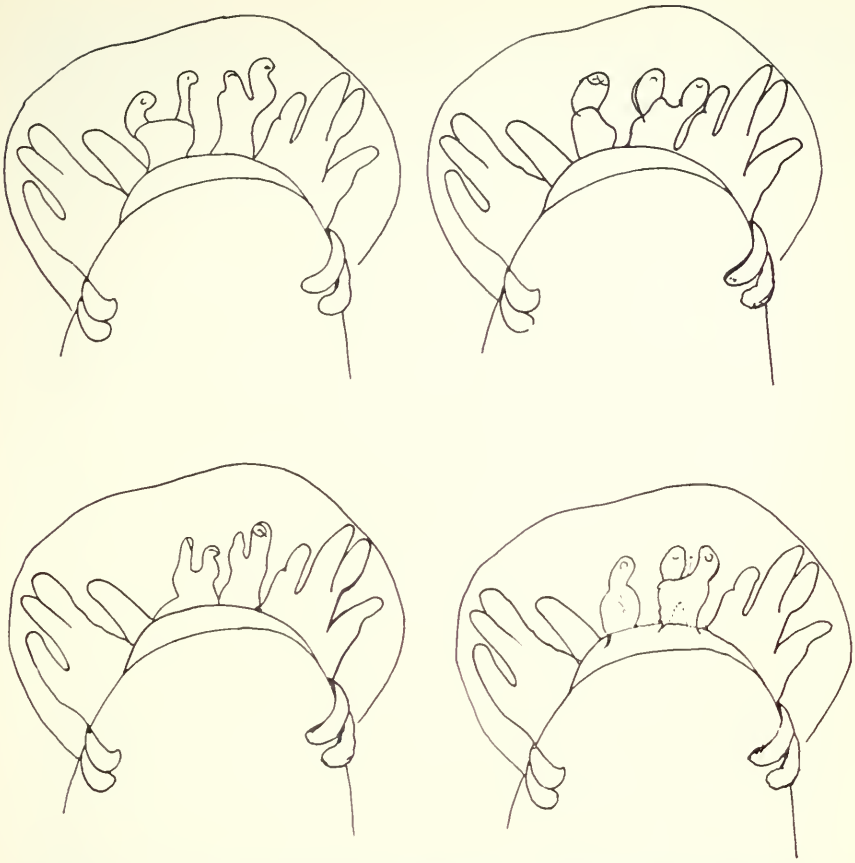

FIGURE 3—Drawings showing variations in structure of the dorsal ray of the male bursa, *P. odocoilei*. *Drawing by Cliffa Corson.*

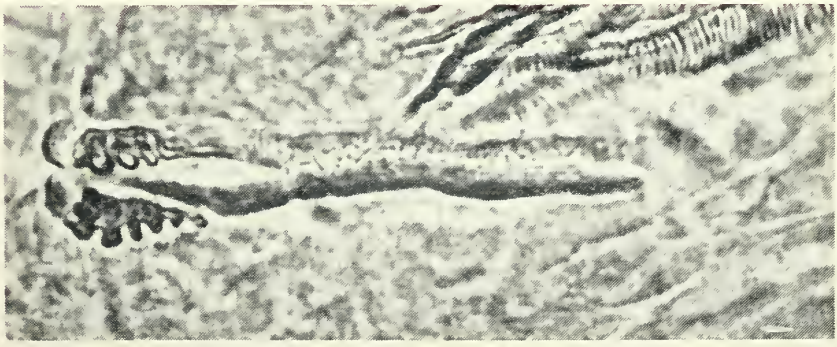

FIGURE 4—View of gubernaculum, *P. odocoilei*.
Photograph by William E. Schafer.

FIGURE 5—Caudal end of female *P. odocoilei*, lateral view.
Photograph by William E. Schafer.

TABLE 1

Principal Measurements of Males

	Average	Range
Length	28.2	(23.8–32.6) mm
Maximum width	115.5	(108.5–122.5) μ
Length of esophagus	723	(675–795) μ
Maximum width of esophagus	78.8	(70–87.5) μ
Nerve ring from anterior end	90.1	(87.5–92.8) μ
Excretory pore from anterior end	77.0	(70–82.3) μ
Length of excretory duct	78.8	(70–87.5) μ
Length of spicules	163.2	(157.5–175.0) μ
Length of crura	19.4	(18.0–21.0) μ
Width of crura	8.75	
Length of corpus gubernaculi	81.4	(75.3–87.5) μ
Width of corpus gubernaculi at widest point	17.5	
Bursa	105 x 78.8	

triangular in outline and when flattened and viewed dorso-ventrally definite notches (4 to 6) are observed, giving a segmented appearance.

The caudal end of the female does not show significant differences from *E. tenuis* (Dougherty, 1945) as described by Whitlock. The vulva is sclerotized and protrudes; the anal plate is also sclerotized and flat (Figure 5). The tail has a sac-like dilation which is apparently cuticle and the tail itself ends in a small papilliform projection. Principal measurements of the nematodes are given in Tables 1 and 2.

Ova and Larvae

Ova are embolized in the lung, where embryonization takes place. Freshly deposited ova are spherical, with a thin shell enclosing a a central dense mass; average diameter is approximately 40μ and no segmentation is apparent.

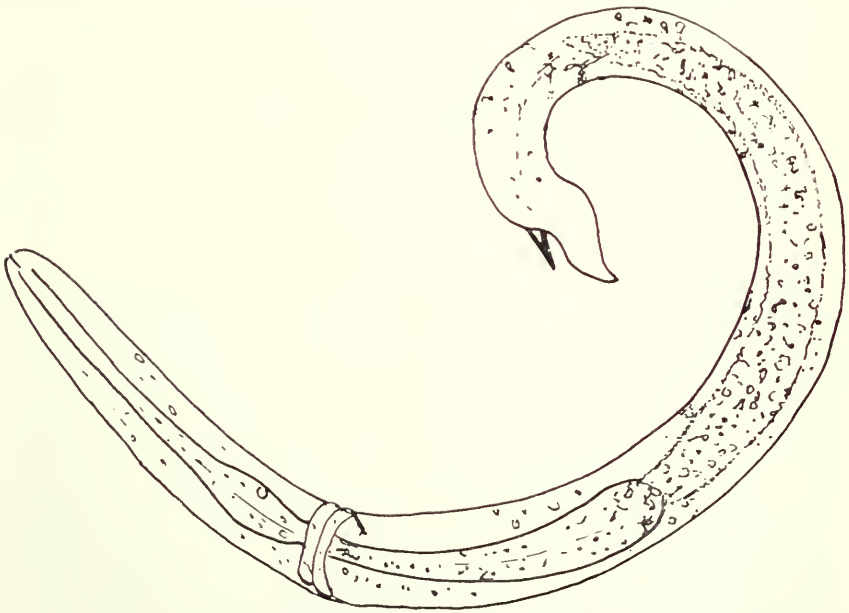

FIGURE 6—First stoge larva, *P. odocoilei*, lateral view.
Drawing by Cliffa Corson.

TABLE 2

Principal Measurements of Females

	Average	Range
Length	49.5	(44.5–56.2) mm
Maximum width	183.3	(154–217) μ
Length of esophagus	878.5	(788–1050) μ
Maximum width of esophagus	84	(70–96.3) μ
Nerve ring from anterior end	85.2	(64.8–103.25) μ
Excretory pore from anterior end	88.4	(75–112.5) μ
Length of excretory duct	80.4	(68–92.75) μ
Vulva from posterior end	160.1	(110–191) μ
Anus from posterior end	50.1	(40–61.25) μ
Length of ovijector	1344.4	(1140–1508) μ

First-stage larvae average 367.5μ in length and have an undulating tail, with a very small dorsal spine (Figure 6). The larvae are very active and can be found in great numbers in the lung both in the nodules and free in the alveoli. Larvae are coughed up and swallowed and may then be found in the intestines and in the mucus coating the fecal pellets. First-stage larvae are resistant to changes of external environment. Larvae remained alive at least 12 months in refrigerated water. Larvae frozen at 0 F were viable after 165 days and larvae allowed to dry on fecal pellets at room temperature were viable after 7 months. This seemed to be related to the amount of mucus coating the pellets, which apparently had a protective effect. Washed larvae survived drying for only 16 days. It is apparent that first-stage larvae could survive after being passed by deer for extremely long periods of time in what might amount to a free-living stage.

PATHOLOGY

Although adult nematodes cause only a small amount of damage in the musculature, a great deal of pathology is produced by ova and larvae in the lymph nodes and lungs. The ova and larvae are in granuloma-like nodules scattered throughout the lung tissue. These granulomas seem to be produced by proliferation of septal and interstitial cells. Occasional giant cells are seen. Capillary hyperemia occurs in the alveolar walls. Ova and larvae occur individually and in groups, surrounded by a fibrous tissue.

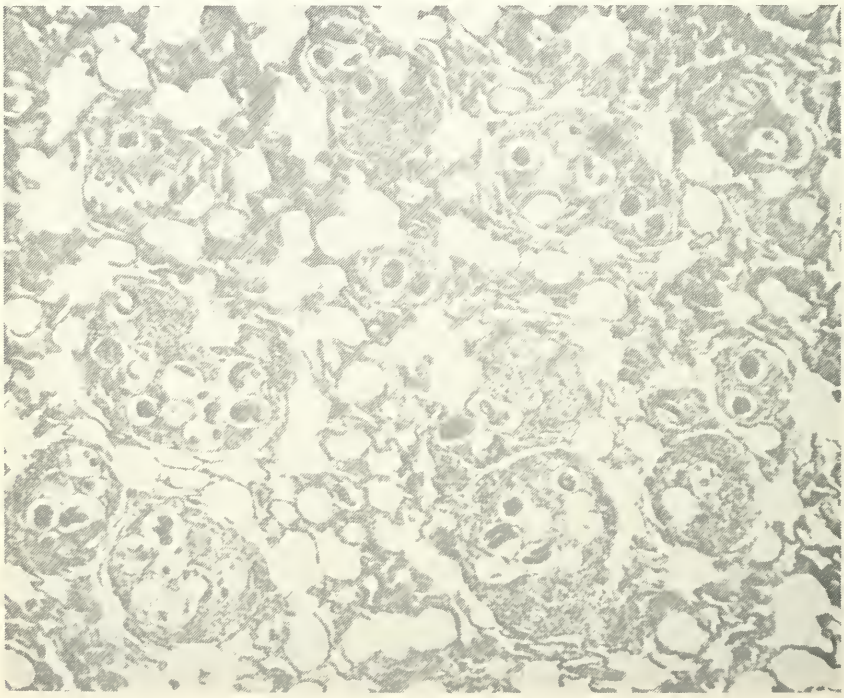

FIGURE 7—Section of deer lung showing granulomas containing ova and larvae of *P. odocoilei*. *Photograph by William E. Schafer.*

Granulomas were variable in size, from small ones containing one or two ova to those which were over 1 mm in diameter with 10 to 20 ova in various stages of development including unsegmented ova and morulated and larvated stages, as well as first stage larvae (Figure 7). The effect on lymph nodes was different. Embolization of ova occurred in the afferent lymphatic vessels, the capsular and trabecular vessels, and in the peripheral sinuses. There was little tendency toward production of granulomatous structures as in the lung. Masses of ova were surrounded by and enmeshed in fibrotic tissue, with some areas of lymphocytic proliferation and occasional groups of giant cells with nuclei in a peripheral position. Many ova in these masses were undergoing degeneration; however, some embryonization was occurring and a few first-stage larvae could be seen, some of which had migrated into the lymphoid tissue. Masses of ova which were deeper in the tissue tended to have more degenerate forms that those on the periphery.

LIFE CYCLE

Little is known of the life cycle of these parasites, regarding the phases which occur in the host. Forms which occur in the eastern white-tailed deer (*O. virginianus*) migrate into the central nervous tissue. In the original description by the Hobmaiers, there was no evidence of these nematodes in tissue anterior to the shoulders. The same condition was found in this study. Careful dissection of the brain, cord, and membranes failed to reveal nematodes.

The life cycle of this parasite involves an intermediate host. The Hobmaiers successfully infected various species of snails and slugs and were able to parasitize a deer by feeding it the infective larvae. After an interval of 4 to 5 months, they recovered first-stage larvae from the feces. In this study several species of snails and slugs, *Helix aspersa*, *Agriolimox agrestis*, *A. campestris*, and *Planorbis* sp., were successfully infected with first-stage larvae from the lungs and fecal pellets. Two black-tailed deer free from natural infection were experimentally infected by feeding snail tissue containing fourth-stage larvae. The infected deer passed first-stage larvae after an interval of 2½ months. Larvae persisted for about 6 months and then disappeared. Subsequent experiments produced the same results. One of these deer died of unrelated causes and dissection of the musculature produced a number of adult nematodes identical with those found in the original deer. In the wild the parasites are obviously acquired by deer from the ingestion of infected gastropods on the vegetation. A limited search for naturally infected snails or slugs was negative.

DISCUSSION

The Hobmaiers gave only a few measurements of their specimens. Those given are not greatly at variance with those of the present specimens. They made no mention of the variable structure of the dorsal ray of the bursa. It is possible their description was based on a single specimen.

Specimens in this study came from the same type host and locality as those of the Hobmaiers and were found in similar localities in the body of the host. There is no doubt that these are the same as the type species.

In 1950 Boev and Schuls placed Hobmaiers' (1934) species in a new genus on the following basis:

Elaphostrongylus Cameron, 1931—Gubernaculum simple, one part. One bifurcated dorsal ray.

Parelaphostrongylus Boev and Schuls, 1950—Gubernaculum consisting of paired corpus and paired crura. Two well-developed dorsal rays, each divided into two branches.

The Hobmaiers' description of the gubernaculum was as follows: "The wall of the ductus genitalis nearby is strengthened by two small chitinous ribbons which measure 67 μ in length."

As can be seen from the description of the gubernaculum of the present specimens, it is a different structure from that described by the Hobmaiers. Because of the thickened edges of the corpus it was apparrent that examination of the structure with the spicules in place could lead to an erroneous picture of the gubernaculum. This leaves the speciation of this parasite in some confusion. All of these closely related nematodes have marked similarities of structure. Anderson (1956) described nematodes from the cranial case of white-tailed deer and concluded that his specimens were *E. odocoilei*, based on similarities to the specimens described by the Hobmaiers. It is now known that these were *Pneumostrongylus tenuis* (Dougherty, 1945), as were Whitloek's specimens (1959).

In 1963 Anderson described the life cycle of *Pneumostrongylus tenuis* in the white-tailed deer. He experimentally infected deer with infective larvae reared in a variety of snail species and described the development of the nematodes in the tissues of the central nervous system.

Marked similarities to the above were found in the studies made with *Parelaphostrongylus*. The morphology of the adults is, with the exception of some measurements, remarkably similar; the ova and larvae are indistinguishable; their development in gastropods is the same. These nematodes seem very closely related; the major difference between them is in the tissue in which they localize. Comparative studies will have to be made of the specimens from various hosts to resolve the question of speciation.

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ON THE OCCURRENCE OF LARVAL CESTODES IN THE WASHINGTON CLAM, *SAXIDOMUS NUTTALLI*, AND THE GAPER CLAM, *TRESUS NUTTALLI*, FROM DRAKES ESTERO, CALIFORNIA[1]

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Larval cestodes (plerocercoids), identified as belonging in the genus *Echeneibothrium*, were observed to be encysted in the foot and free in the lumen of the intestine of the gaper clam, *Tresus nuttalli*. Encysted larvae were not noted in the Washington clam, *Saxidomus nuttalli*, although several clams were observed with larvae in the lumen of their intestine. A ciliated embryonic form was observed in sectioned material from the intestine of the gaper clam, and two larval stages, apparently intermediate between the ciliated embryo and the pleracercoid, were noted in the intestine of a Washington clam.

INTRODUCTION

Larval cestodes have been reported from clams by MacGinitie and MacGinitie (1949), Hyman (1951), Sparks and Chew (1966), Cheng (1967), Katkansky and Warner (1969), and Warner and Katkansky (1969a, 1969b). MacGinitie and MacGinitie (1949) reported a species of *Anthobothrium* from the foot of a gaper clam, *Schizothaerus* (= *Tresus*) *nuttalli*, but remarked on the lack of infestation in Washington clams of similar size and occurring in the same bed. They speculated that Washington clams must ingest cestode larvae, since they feed in the same manner as gaper clams.

During routine examinations, we observed cestode larvae encysted in the foot of gaper clams and free in the lumen of the intestine of gaper and Washington clams. Larval forms which we consider to be precursors of the plerocercoid stage, were noted in both clams. Since the complete life cycle of this genus of cestodes is unknown, it seems appropriate to report our observations as a contribution to the life history of the genus *Echeneibothrium*.

METHODS AND MATERIALS

Monthly samples of not less than 10 Washington and 10 gaper clams were collected from Drakes Estero, about 30 miles north of San Francisco, California, from April through December 1968. A 5-mm cross section from the foot of each clam was fixed in Davidson's solution (Shaw and Battle, 1957, p. 326), processed using standard histological techniques, and stained with hematoxylin and eosin. Cysts were recovered from the visceral mass of gaper clams; the plerocercoids were excysted, examined, and photographed. Living larval cestodes were removed from the intestinal tract of Washington clams, examined, and photographed.

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FIGURE 1—Plerocercoid larvae encysted in a gaper clam, *Tresus nuttalli*.

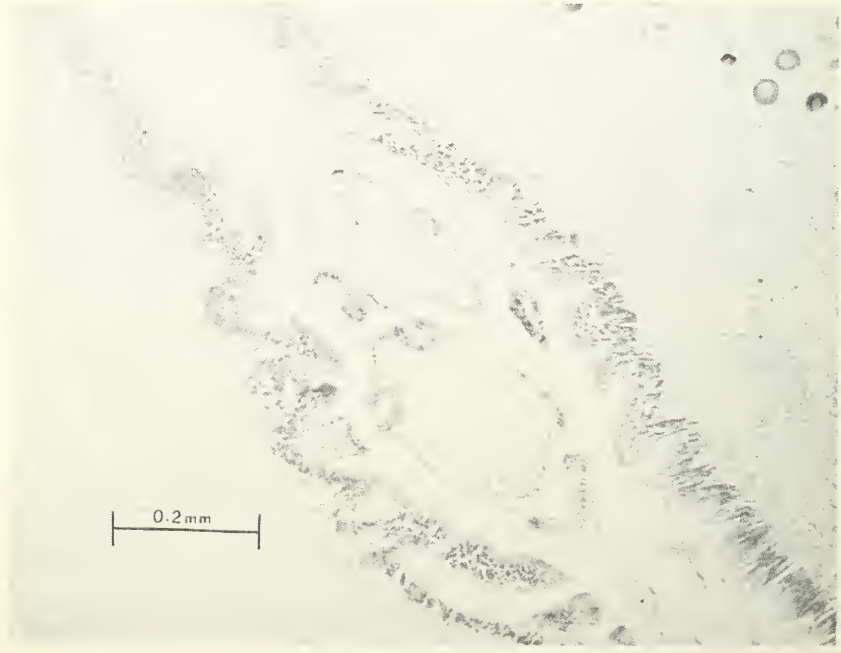

FIGURE 2—Plerocercoid larvae free in the lumen of the intestine of the gaper clam, *Tresus nuttalli*. Similar larvae were noted from the intestine of a Washington clam, *Saxidomus nuttalli*.

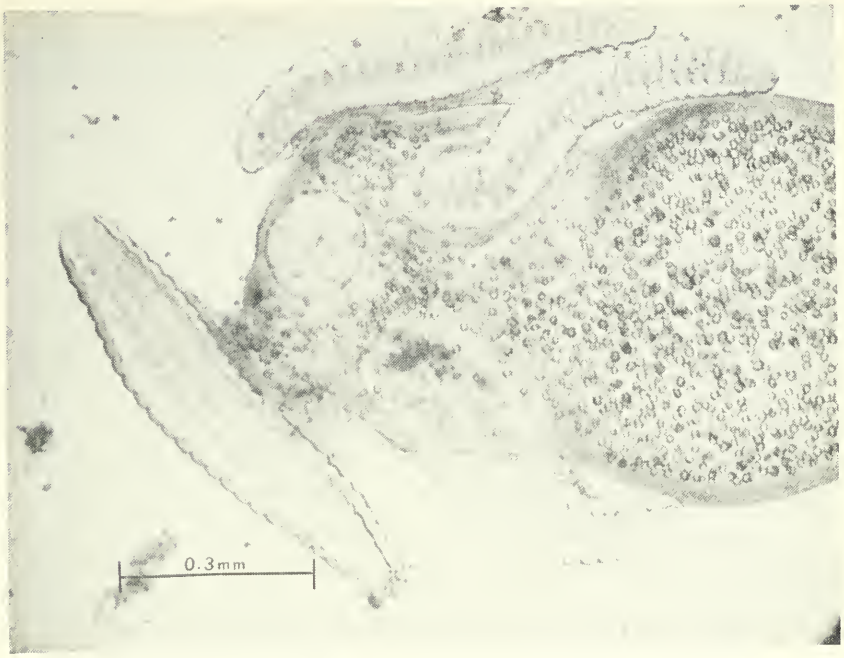

FIGURE 3—Plerocercoid larva excysted from a gaper clam, *Tresus nuttalli*.

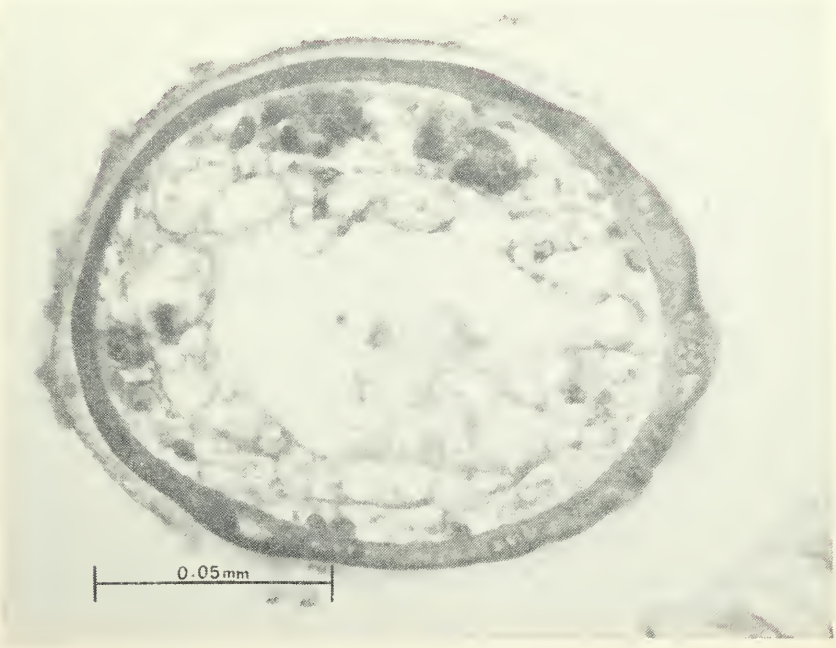

FIGURE 4—Cross section through the ciliated embryonic cestode in the intestine of a gaper clam, *Tresus nuttalli*.

RESULTS

Microscopic examination of histological preparations from gaper clams revealed plerocercoid larvae encysted in the foot of nearly every clam examined (Figure 1). A few gaper clams were observed with plerocercoids in the lumen of their intestine (Figure 2). Similarly, plerocercoids were noted in the intestinal lumen of several Washington clams; however, encysted cestodes were not observed.

The live plerocercoids from the intestine of the Washington clams matched the description of *Echeneibothrium maculatum* given by Wardle and McLeod (1952). The plerocercoids excysted from gaper clams (Figure 3) could not be identified, since the number of loculi on their bothridial surfaces exceeds that of any species described. Difficulty in identifying *Echeneibothrium* to the species level was noted by Warner and Katkansky (1969a). They concluded that such difficulties were caused by possible intraspecific variations in taxonomic characters and by the number of undescribed species.

Cheng (1967) points out that the life cycle of *Echeneibothrium* has not been determined. We have observed larval stages in the intestine of both Washington and gaper clams which are apparent precursors of the plerocercoid stage. A ciliated cestode was found in the intestine of a gaper clam (Figure 4). Examination of the intestinal contents of several Washington clams has revealed two additional stages which appear intermediate between the ciliated embryo and the plerocercoid.

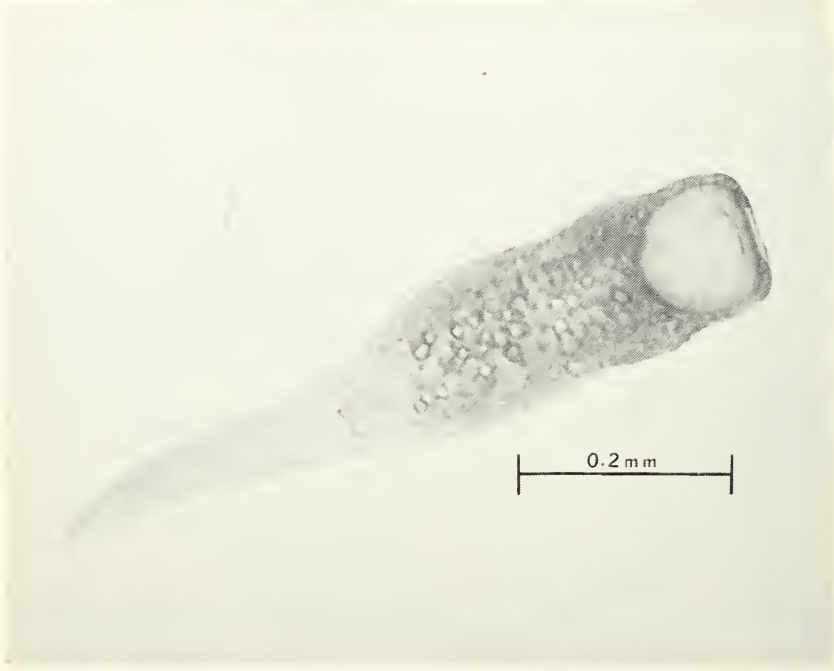

FIGURE 5—A "pre-plerocercoid" larva from the intestine of a Washington clam, *Saxidomus nuttalli*.

One form appeared as an oval body slightly pointed at one end with an opening at the other. We considered this to be a developing plerocercoid, with the opening representing a rudimentary myzorhynchus. Unfortunately, photomicrographs of this form are not available. A more advanced form (Figure 5) resembles the plerocercoid with the exception of the missing bothridia. It is probable that the bothridia are the last anatomical features to develop.

DISCUSSION

Since the complete life cycle of any species of *Echeneibothrium* is unknown, we only can speculate on the exact meaning of our observations. It appears that the clam ingests either the egg or the ciliated embryo of the cestode. If the egg is ingested, it hatches into the ciliated embryo in the intestine of the clam. The embryo penetrates the intestinal tract of the host, develops, and encysts as a plerocercoid. Plerocercoids have been noted in the intestine of the gaper clam. We may speculate that the larvae were unable to penetrate the clam's intestinal epithelium and metamorphosis occurred in the intestinal lumen. Since encysted cestodes have not been observed in Washington clams, we conclude that this clam is not a suitable host and penetration is somehow prohibited. It is possible that the plerocercoids in the intestinal lumen are voided from the host after a period of time.

The definitive host for the cestode found in these clams is probably an elasmobranch. MacGinitie and MacGinitie (1949) and Sparks and Chew (1966) implicated the bat stingray, *Myliobatis californicus,* as the definitive host for larval cestodes they found in clams.

The cestode figured by MacGinitie and MacGinitie (1949) as *Anthobothrium* is very similar to the cestodes we have identified as belonging in the genus *Echeneibothrium*. MacGinitie and MacGinitie apparently were not sure of the taxonomic position of their cestode since they labeled it as "*Anthobothrium* sp. ?". The genera *Echeneibothrium* and *Anthobothrium* are separated by the structure of the bothridia. *Echeneibothrium* possesses bothridia which are transversely ridged or compartmented, while *Anthobothrium* possesses bothridia which are not. Wardle and McLeod (1952) indicated that the bothridial surfaces of *Anthobothrium* may have the appearance of compartmentation under certain conditions of expansion. Rees (1943) indicated that "indefinite loculi" are noted in the contracted bothridia of *Anthobothrium auriculatum*. He further stated that these were not true loculi, since the intervening walls are formed from longitudinal muscles passing from the peduncle. Examination of the bothridia as figured by Rees reveals no similarity to the bothridia of the cestodes we observed. We have examined living plerocercoids under conditions of expansion and contraction, and definite compartmentation is present (Figure 3). Examination of fresh material, as well as fixed, sectioned material, reveals definite compartmentation. We therefore concluded that the plerocercoid identified as *Anthobothrium* sp. by MacGinitie and MacGinitie is, in fact, *Echeneibothrium* sp.

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NOTES

VERTEBRAL COLUMN DEFORMITY AND OSTEONECROSIS OF PELVIS AND FEMUR IN THE CALIFORNIA SEA LION

On December 18, 1966, during a trip to Ano Nuevo Island, 40 miles south of San Francisco, with Stanford Research Institute biologists, a male California sea lion, *Zalophus californianus*, in extremely poor condition was collected under permit in order to investigate the nature of a large swelling of the lumbar region. The specimen weighed approximately 300 lb.

The lumbar region of the vertebral column was deformed. Grossly it resembled a kyphoscoliosis of the spine. The specimen was fleshed and the complete skeleton was taken for study. No abscesses or lesions were noted anywhere on the carcass. A high level of helminth parasitism, however, was noted not only within the stomach and the intestines but also in the lungs and diaphragm, as well as in muscles of the abdominal wall, anterior serratus, intercostalis, and subscapularis muscles.

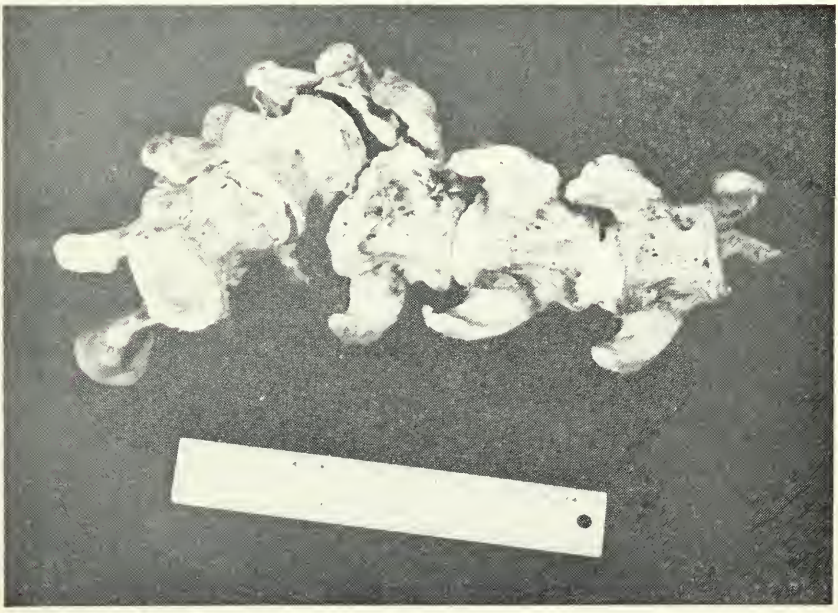

FIGURE 1—Ventral view of the last thoracic vertebra and five lumbar vertebrae. The second lumbar vertebra, third from the left, shows complete necrosis of the centrum. The spinal cord, though still housed by the neural arch, was somewhat pinched and formed a sigmoid curve. *Photograph by Morton Boss.*

FIGURE 2—Left side view of the pelvis, sacral vertebrae, and left femur, showing near complete necrosis of the left ilial crest, acetabulum, and capitulum and trochanter of the left femur. Bony sequestra, remnants of the ventral edge of the ilium, are seen at lower left. *Photograph by Morton Boss.*

A search of the literature did not reveal a previous record of this anomalous condition. The curvature of the spine in the region of the lumbar vertebrae was apparently caused by complete osteonecrosis of the second vertebral centrum and its accompanying intervertebral discs. All that remained of the second lumbar vertebra, therefore, was the neural arch with its associated spine and zygapophyses, as well as the transverse processes. Subsequent bone repair involved fusion of post-zygapophyses of the second lumbar vertebra to the prezygapophyses of the third lumbar vertebra and fusion of the right transverse process of the second lumbar to the anterodorsal face of the centrum of the third lumbar (Figure 1). The spinal cord was undamaged, but it was markedly displaced in a sigmoid curve.

Near complete necrosis of the left ilium had taken place, involving also loss of the acetabulum and approximately one-third of the proximal end of the femur. Osseous sequestra were all that remained of the anterior ventral edge of the left ilium (Figure 2). The right side of the pelvis and right femur were unaffected (Figure 3). The mandibular fossae and the articulating condyles of the mandibles of the skull also indicated considerable necrosis.

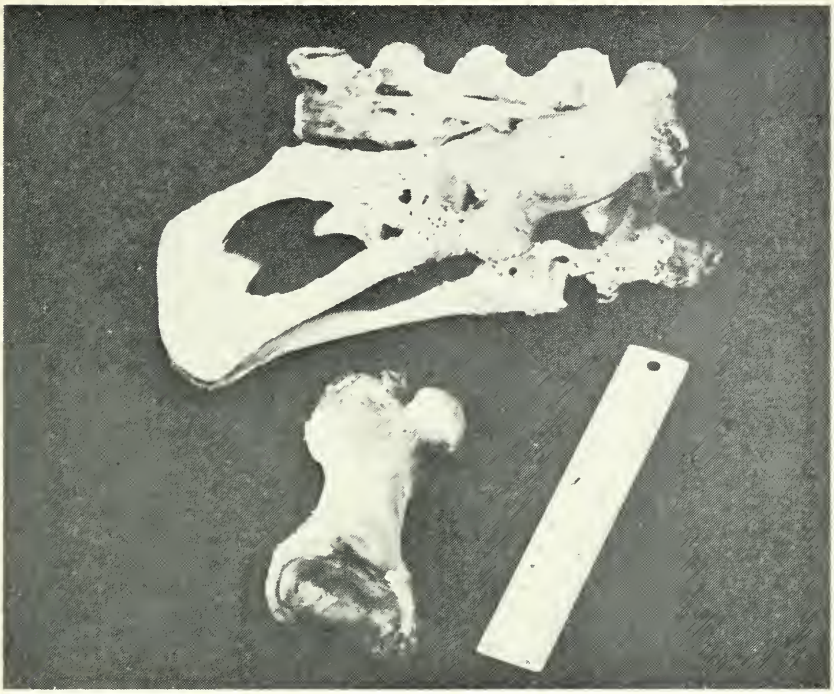

FIGURE 3—Normal right side view of the pelvis, sacral vertebrae, and right femur, showing little effect of the condition seen on the left side.
Photograph by Morton Boss.

The cause of this anomalous condition was not determined. Although the bone damage resembles Pott's disease or tuberculosis of the spine as described for humans (Homans, 1932; Boyd, 1943), the lack of typical tubercular lesions in surrounding tissues and the lack of evidence of a primary lesion would seem to preclude tuberculosis as the cause. Actually, there are a number of conditions related to disease, nutrition, or injury which produce bone lesions without surrounding tissue reactions.

Abnormal tooth wear on the anterior faces of the upper incisors and the tips of the lower canines (Figure 4) may indicate that this animal, no longer able to swim fast enough to catch fish, had been feeding extensively upon rock-dwelling mollusks. Similar tooth wear has been reported by Hildebrand (1954) for the sea otter, *Enhydra lutris*. This type of abnormal tooth wear, for the sea lion, has been noticed on skulls of carcasses of old California sea lion bulls that wash up on beaches of Ano Nuevo Island and vicinity. Perhaps due to old age or illness these animals resort to other means of food capture to survive.

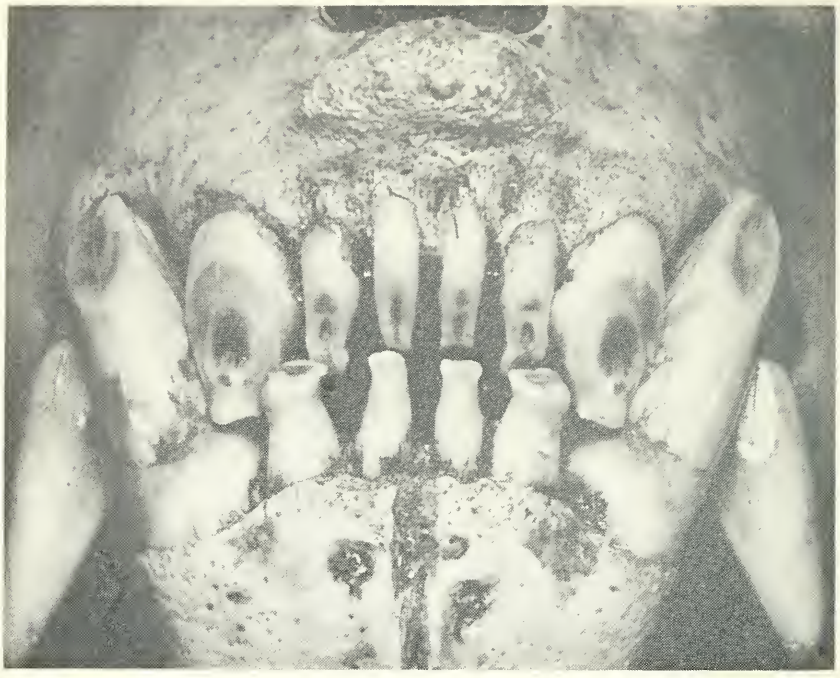

FIGURE 4—Unusual wear on the anterior surfoces of the upper incisors and tips of lower canines, probably caused by feeding on encrusting mollusks. *Photograph by William E. Ferguson.*

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—*G. Victor Morejohn, Moss Landing Marine Laboratories, Moss Landing, California 95039.* *Accepted February 1969.*

OCCURRENCE OF THE NEMATODE, *PHILOMETRA AMERICANA*, IN THE ENGLISH SOLE, *PAROPHRYS VETULUS*, IN SAN FRANCISCO BAY

Several species of nematodes belonging to the genus *Philometra* occur in the body cavities and tissues of freshwater and marine fishes in North America. The nematode *P. americana* was first described by Kuitunen-Ekbaum (1933) from a starry flounder, *Platichthys stellatus*, collected at Departure Bay, Vancouver Island. He also observed this nematode in the rock sole, *Lepidopsetta bilineata*, the black prickleback, *Xiphister atropurpureus*, the saddleback gunnel, *Pholis ornatus*, and the northern clingfish, *Gobiesox meandricus*.

This is the first reported occurrence of *P. americana* in the English sole, *Parophrys vetulus*. Infections were found in 9 of 359 juvenile sole (80–120 mm) collected by otter trawl in 40 to 50 ft of water on the west side of Treasure Island in February 1966. One of 250 juvenile fish collected in this area in November 1966 was found infected. During December 1966, we collected 500 juvenile English sole on the east side of Treasure Island in 40 to 50 ft of water. One was infected. The number of worms ranged from 1 to 22 per fish and characteristically they were located under the skin at the bases of fins. In all cases, the nematodes were blood red females, but only those collected in November contained live embryos in the uterus. In no case was a male worm found.

Although the complete life cycle of these parasites is not known, it is believed to involve a planktonic intermediate host, possibly a copepod. Kuitunen-Ekbaum (1933) suggested that the female worm

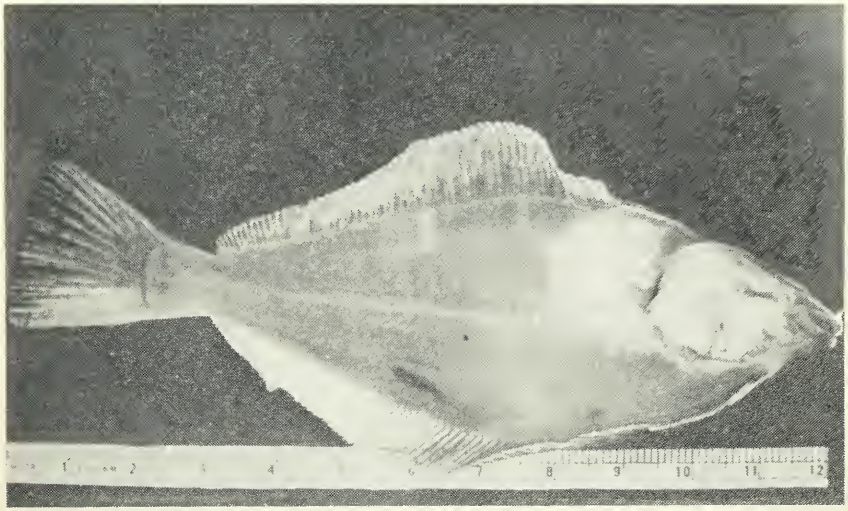

FIGURE 1—The immature nematodes are barely visible at the base of the dorsal fin.

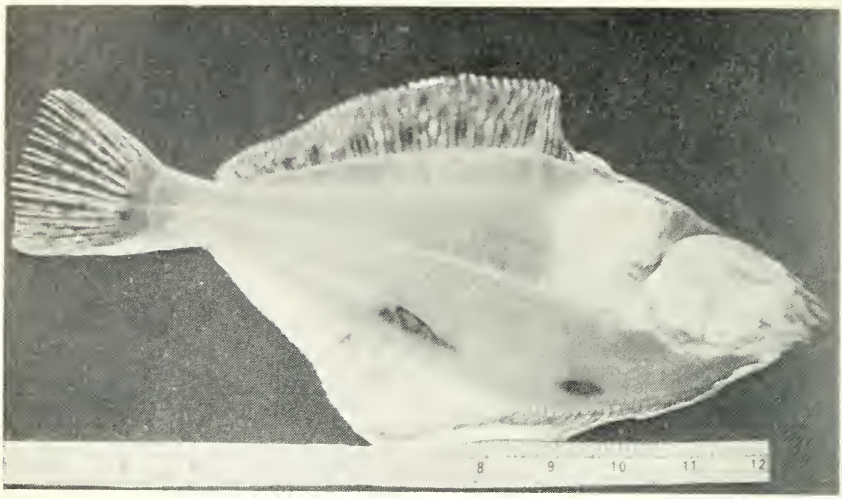

FIGURE 2—The nematodes are clearly distinguishable.

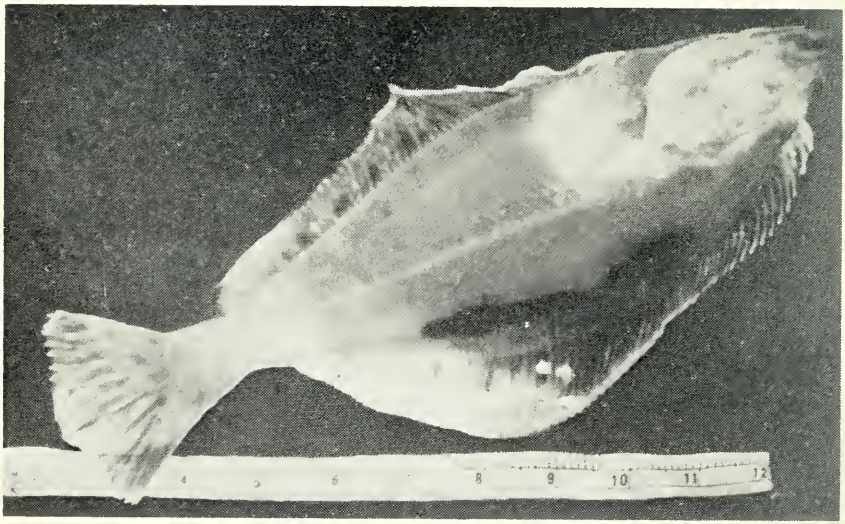

FIGURE 3—The nematodes are approximately 50 mm in length, blood red, and exhibit vigorous movement.

bores her way through the skin of the host and extrudes the larvae into the seawater, where they are eaten by plankton and undergo partial development. Development is completed in the definitive host when the plankters are eaten.

An indication of the development rate of the female worms in juvenile English sole was gained by observing a fish in captivity (Figures 1–3). The fish was collected on February 4, 1966, on the west side of Treasure Island, was kept in a jar of filtered seawater at approximately 20 C, and fed brine shrimp, *Artemia salina*. On

February 24, 1966 (Figure 1), two immature nematodes were barely visible as pale red foci at the base of the dorsal fin; by March 9 (Figure 2), the nematodes were clearly distinguishable; and on May 11 (Figure 3), the nematodes had reached approximately 50 mm in length, were characteristically blood red, and exhibited vigorous movement. Grossly, there appears to be little tissue damage or host response in the vicinity of the worms in juvenile fish.

On March 6, 1967, the Department of Fish and Game vessel *Nautilus* took 322 adult English sole (300–400 mm) in an otter trawl approximately 6.5 miles south of Seal Rock, 2.2 miles offshore in 90 ft of water. None of these fish was infected with these nematodes nor were there any signs of previous infection. However, considering the apparent low incidence of these nematodes in juvenile fish, larger samples of adult fish must be examined before conclusions may be drawn regarding the occurrence of nematodes in adults.

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Joseph J. Di Conza, Division of Parasitology,[1] and *Robert C. Cooper, School of Public Health, University of California, Berkeley.* *Accepted April 1969.*

[1] Present address: Department of Parasitology, University of Queensland, St. Lucia, Qld., Australia.

MORTALITY OF COMMON MURRES ALONG THE NORTHERN CALIFORNIA COAST

During the months of July through September 1968, mortality of common murres (*Uria aalge californica*) occurred along the northern California coast from Monterey Bay north. Both mature and immature birds were found. Counts and observations at various localities along the North Coast were made by the author and others (Table 1). The area covered represents only a small portion of the coastline.

Specimens collected from Salmon Creek beach, Sonoma County, and Shelter Cove and Mattole River beach, Humboldt County, were autopsied. Twenty specimens examined by pathologists at the Veterinary School at the University of California, Davis, did not reveal positive diagnosis for pathogenic bacteria or abnormality in the organs or tissues.

A paralytic shellfish poison similar to that produced by the dinoflagellate *Gonyaulex catenella* was suspected. An attempt was made by the author to extract an alkaloid poison from the gut contents through the use of a diphasic, organo-aqueous, extraction technique. Two mice injected with the extract in an aqueous diluent died within 5 minutes; however, this test was not conclusive for alkaloid poisoning.

Tests run by the Pesticides Investigations project, California Department of Fish and Game, revealed what is suspected to be above normal concentration of DDE in the brain tissue of the six common murres examined. However, such findings are not conclusive evidence that this was the cause of death.

List of Dead and Dying Common Murres Found in 1968

Date	Number	Locality	Observer
July 16	31[1]	Moss Landing, Monterey County	Robert Jones and Jim Faro, Humboldt State College
July 30	30[2]	Shelter Cove, Humboldt County	Richard T. Burge, Calif. Dept. Fish and Game
July–August[3]		10-mile radius, St. George Reef Light, Del Norte County	Lt. Wayne Klein, Calif. Dept. Fish and Game
Aug. 5	19	Shelter Cove, Humboldt County	Carl F. Miller, Calif. Dept. Fish and Game
Aug. 11	10	Mattole River to Cape Mendocino, Humboldt County	Jones and Faro
Aug. 12	3[4]	Salmon Creek Beach, Sonoma County	John Bodle
Aug. 13	15	Horseshoe Cove, Sonoma County	John Bodle
Aug. 13	31	Salmon Creek Beach, Sonoma County	John Bodle
Aug. 14	12	Horseshoe Cove, Sonoma County	Janet Bodle
Aug. 15	2	Horseshoe Cove, Sonoma County	Bob Sikora
Aug. 18	500	Beach north of Mattole River, Humboldt County	Jones and Faro
Aug. 19	1	Horseshoe Cove, Sonoma County	John Bodle
Sept. 10	6	Samoa Peninsula to Little River, Humboldt County	Jones and Faro
Sept. 12	52	Eel River to South Spit of Humboldt Bay, Humboldt County	Jones and Faro

[1] Other dead birds found were 18 sooty shearwaters, 5 western grebes, and 13 gulls.
[2] Dead and dying common murres were reported from Punta Gorda north to Crescent City.
[3] Several to more than 100 dead birds were observed during daily patrol of offshore waters by the patrol boat "Rainbow" from mid-July to late August.
[4] Number discovered after searching 100 yards of the mile-long beach.

Tests for chlorinated hydrocarbons are continuing both on specimens found dead and specimens collected in November by shooting.

Researchers at the University of California Bodega Marine Laboratory observed a similar mortality at about the same time in 1967. This suggests that such mortalities may be of seasonal occurrence.

In the event a future mortality occurs, a concerted effort should be made to identify its cause.

—John E. Bodle, Department of Zoology, University of California, Davis, California. Accepted April 1969.

ADDITION OF *MISGURNUS ANGUILLICAUDATUS* (CANTOR) TO THE CALIFORNIAN FAUNA

On April 12, 1968, the senior author discovered loaches in a portion of the Westminster flood control channel, Orange County. This was the first verified record of free-living loaches in California.

The location of the first observation was adjacent to the south boundary of the Pacific Goldfish Farm on Bolsa Avenue between Edwards and Golden West Streets in Westminster. Subsequent surveys have revealed that the range extends west to Graham Street, and northeast to a railroad overpass west of Central Memorial Park. We found loaches in approximately 3 miles of the 9.5-mile long channel. It appears that their range has been presently limited to this section because of tidal action to the west and intermittent water flows to the east.

Carl Hubbs, Scripps Institution of Oceanography, identified the loaches as *Misgurnus anguillicaudatus,* the Japanese weatherfish. Specimens have been deposited in the Scripps fish collection (SIO 68-213).

Five surveys were made during the period April 12, 1968, through July 20, 1968. The following 12 species of fishes, 3 species of exotic snails, and 1 species of exotic frog were found:

Japanese weatherfish—*Misgurnus anguillicaudatus*	Mosquitofish—*Gambusia affinis*
Guppy—*Lebistes reticulatus*	Carp—*Cyprinus carpio*
Swordtail—*Xiphophorus helleri*	Goldfish—*Carassius auratus*
Sunset variatus—*Xiphophorus variatus*	Bluegill—*Lepomis macrochirus*
Platy—*Xiphophorus maculatus*	Mystery snail—*Ampullaria cuprina*
Molly—*Poecilia sphenops*	Papershell snail—*Lymnaea auricularia*
Angelfish—*Pterophyllum* sp.	Japanese livebearing snail—*Viviparus malleatus*
Zebrafish—*Brachydanio rerio*	African frog—*Xenopus laevis*

We believe that the place of origin of the loaches and other exotics is the Pacific Goldfish Farm. All of the exotics collected are handled by the farm. Joe Akiyama, owner of the farm, informed us that loaches were reared in an outdoor pond during the 1930's and that some escaped into the channel. Although loaches are no longer reared in ponds, a few could escape from the indoor tanks, since waste water from the farm still flows into the channel.

We collected approximately 300 loaches, which ranged from 16 to 224 mm TL. Numerous others were observed but not collected. The large number present in this channel, and the evidence of reproduction demonstrated by the size range, denotes that the present population did not result entirely from escapement.

The Japanese weatherfish is native to northeastern Asia southward to central China. Its appearance and way of life correspond very closely to those of the European weatherfish, *M. fossilis*. The ability of *Misgurnus* to breath atmospheric air, allowing it to survive in waters of low oxygen content, is described by Sterba (1966): "Intestinal repiration is commonly made use of; the fishes come to the surface, swallow air and force this into the richly-vascular hind-gut. At almost regular intervals the exhausted air then escapes in large bubbles from the vent." These loaches also exhibit a characteristic of burrowing into the substrate. These characteristics make it difficult to eliminate them, should this be desired. *M. anguillicaudatus* is now established in Michigan (Schultz, 1960).

Loaches reportedly are being used as a bait fish in other waters; therefore, the possibility exists that the species will become introduced into sport fishing waters. The relationships of this fish with game fishes are as yet unknown.

We conclude from our observations that *M. anguillicaudatus* is now established in California.

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—*James A. St. Amant and Franklin G. Hoover, Inland Fisheries, Region 5, California Department of Fish and Game.* *Accepted April 1969.*

DIFFERENTIAL STREAMER AND DISK TAG LOSS BY SURFPERCH IN HUMBOLDT BAY, CALIFORNIA

A tagging program was initiated in 1966–67 in Humboldt Bay, California, located about 250 miles north of San Francisco, to determine movements of six species of surfperch, Embiotocidae: redtail surfperch, *Amphistichus rhodoterus*, shiner perch, *Cymatogaster aggregata*, striped seaperch, *Embiotoca lateralis*, walleye surfperch, *Hyperprosopon argenteum*, white seaperch, *Phanerodon furcatus*, and pile perch, *Rhacochilus vacca*. One objective of this program was to determine the most effective type of tag to use on surfperch. The following report is a discussion of the findings related to this particular objective.

MATERIALS AND METHODS

Surfperch for tagging were collected by otter trawl, beach seine, and hook and line.

The fish were tagged with modified streamer and Petersen disk tags. The streamers, made from vinyl "spaghetti" tags, were 4 to 6 inches long, and each had a 0.25- to 0.5-inch piece of 0.026-inch diameter single-strand stainless steel wire in one end. This wire fit snugly inside the hollow streamer and was bent to form a hook for attachment (Miller, Odemar, and Gotshall, 1967). The Petersen tags were 0.56-inch diameter plastic disks attached with stainless steel wire pins (Figure 1).

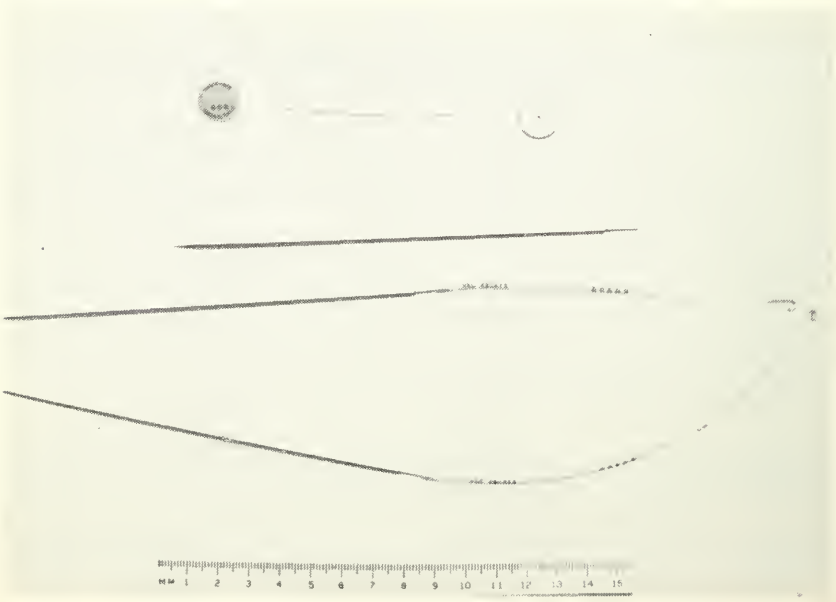

FIGURE 1—Petersen disks with pin and streamer tags with needles.
Photograph by Cecil C. Smith

Streamer and Petersen disk tags were used, even though each has known shortcomings (Davis, 1959; Chadwick, 1963; Kruse, 1964). These tags were alternated on the fish with the exception of fish smaller than 150 mm FL, which were tagged with short streamers.

The surfperch were identified, measured, and sexed at the time of tagging. Initially, the fish were anesthetized with MS 222 (McFarland, 1960), but this proved to be unnecessary. The Petersen disks were applied between the insertion of the dorsal fin and the back of the head. This area is relatively free of movement and allows the pin to pass through the extension of the supraoccipital bone of the skull (Carlisle, Schott, and Abramson, 1960). Streamers were attached to the fish below the anterior end of the dorsal fin. The blunt end of a 0.09-inch diameter stainless steel needle was inserted into the end of the tag opposite the hook. The needle and tag then were passed through the fish so that the tag angled toward the caudal fin. The hook of the tag was tucked under the skin and scales and pulled gently until it caught on the pterygiophores. The needle was then twisted free of the tag.

I expected to get tagged fish returned from the sport fishery, the commercial fishery, and sampling by Humboldt State College personnel. Posters explaining the program were put up in fishing tackle stores and at sport fishing locations on the bay. An article appeared in both of the local daily newspapers near the start of the tagging program. I also contacted commercial fishermen, floormen of fish buying plants, and the California Department of Fish and Game. A total of 817 surfperch was tagged, with 30 (3.7%) returned during the first 20 months.

DISCUSSION

Two factors which could affect tag loss must be considered before the problem of tag loss itself can be properly examined. One is incomplete tag reporting, which can result from either failure to report tags or overlooked tags. However, I believe that in this study nearly all the recovered tags were reported.

The second factor is tagging mortality. This may be caused directly or indirectly by the tag. I attempted to estimate tagging mortality by observing 22 tagged surfperch, representing 5 species, for 95 days in a 500-gal marine aquarium. Two surfperch died in about a month. These had been injured before tagging and their wounds were continually picked upon by other surfperch; however, the actual tag wounds of the two fish were almost healed when the fish died. Two other surfperch were held for a year and were still alive at the conclusion of the study. Their tag wounds had completely healed. As a result of these observations, I believe that mortality resulting from tagging was probably low.

Tagging mortality of surfperch was also considered low in two other studies. Alan J. Beardsley (Oregon State University, pers. comm.) and Morgan (1961), working in Yaquina and Siletz Bays, Oregon, respectively, felt that mortality caused by tagging surfperch with dart tags and Petersen disks was not an important factor affecting tag recovery.

Observations of surfperch (under 150 mm FL) in aquaria revealed that most fish tagged only with streamers lost their tags. Two small

surfperch caught by hook and line during tagging operations had streamer tag scars. The tag losses of smaller fish both in captivity and in the wild indicate the futility of using streamer tags on small surfperch. Disk tags were not used on these fish because of the tag weight and size in relation to fish size.

Two larger fish, one in captivity and one in the wild, also lost streamer tags. I observed no loss of disk tags.

A greater streamer tag loss is indicated by a difference in return of the two tag types. Of 657 fish over 150 mm FL, 349 were tagged with streamers and 308 with disks. Eleven streamer-tagged fish (3.2%) were returned as compared with 19 disk-tagged fish (6.2%), even though a χ^2 test failed to show a significant difference. Of the 14 recaptured fish that were at liberty over 30 days, 12 were tagged with disks.

Beardsley and Morgan in their studies also experienced considerable tag loss by surfperch. Beardsley found a 60% loss of dart tags from surfperch over a 3-month period. Morgan observed a number of recaptured fish with scars from lost disk tags. These disks were placed near the junction of the spinous and soft dorsal fins and thus the pins did not pass through any bony structure, as did the pins for this study. This may have been the reason for the considerable tag loss by the Siletz Bay surfperch.

According to the results of this study, and those of Beardsley's study, surfperch shed tags of the streamer type to a considerable extent. I recommend the disk-type tag as one more suitable for these fishes.

ACKNOWLEDGMENTS

Several Humboldt State College students helped directly with this study. They are Mary Nordstrom, Terry McBee, and Fred Smith. Daniel W. Gotshall, J. Gary Smith, and L. B. Boydstun of the California Department of Fish and Game contributed data, help, equipment, and references for this project.

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—*Allan K. Smith, Humboldt State College, Arcata, California (now at Walter Reed Army Institute of Research).* *Accepted February 1969.*

OCCURRENCE OF THE SPOTFIN SURFPERCH IN OREGON WATERS

A spotfin surfperch, *Hyperprosopon anale* Agassiz, was collected from the surf near Seal Rock, Oregon (lat. 44° 29′ 55″ N, long. 124° 04′ 56″ W) on June 26, 1968, extending the reported northern limit for this species approximately 425 sea miles. The recorded range is from Blanca Bay, Baja California, northward to Bodega Bay, California (Tarp, 1952; Roedel, 1953; Miller, Gotshall, and Nitsos, 1965). This specimen was taken by hook and line along with redtail surfperch, *Amphistichus rhodoterus* (Agassiz), and silver surfperch, *Hyperprosopon ellipticum* (Gibbons).

The specimen was a 161-mm SL (199-mm TL) female, weighing 142 g, and in her 4th year of life based on scale analysis. This is larger than the mean standard length of 98.5 mm (50.0 to 136.5 mm) for 50 specimens reported by Tarp (1952) and the length "to 6 inches" given by Miller et al. (1965). The female contained 20 embryos with a mean standard length of 38.4 mm (50.6 mm TL) and a mean weight of 1.41 g. Based on their morphology, the embryos were judged to be near term.

Possible failure to report this species north of Bodega Bay could be because of its small size and because it is seldom taken by hook and line. The spotfin can be easily separated from the other two species of silver-colored surfperches (the silver surfperch, *H. ellipticum* (Gibbons), and the walleye surfperch, *H. argenteum* (Gibbons)) common to the central coast of Oregon by a characteristic black spot on its spinous dorsal and a smaller black spot on its anal fin. The specimen was deposited in the ichthyological collection of the Department of Fisheries and Wildlife, Oregon State University—accession number OSU 2568.

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Richard S. Wydoski, Oregon Cooperative Fishery Unit, Marine Science Center, OSU, Newport, Oregon. (Now with Washington Cooperative Fishery Unit, 106 Fisheries Center, University of Washington, Seattle, Washington 98105.)

Accepted May 1969.

OCCURRENCE OF *PRIONOTUS STEPHANOPHRYS* OFF THE COLUMBIA RIVER[1]

A specimen of the lumptail searobin, *Prionotus stephanophrys* Lockington, was among fish in trawl catches of the M/V *Nestucca* during June 28 and 29, 1961. Catches were made 11 to 17 miles off the Columbia River mouth between North Head and Leadbetter Point at depths of 53 to 56 fathoms. The junior author, then an employee

of the Fish Commission of Oregon, identified the specimen and presented it to Oregon State University. This is the first known occurrence north of California. Hubbs (1945) reviewed the California distribution, noting it to be southward from San Francisco. Fitch (1951) lists specimens from off Point Fermin and from Santa Maria Bay, Lower California, and Radovich (1961) mentions additional collections from southern California.

Our specimen (OS 1294) is 137 mm long (Table 1), much smaller than the one discussed by Hubbs (1945) and slightly smaller than the type specimen (Lockington, 1881). Counts are as follows: dorsal fin X-12; anal fin I, 10; caudal fin 11; pectoral fins 13; gill rakers 4 + 20; branchiostegals 7; lateral line pores 51.

[1] Technical Paper No. 2597, Oregon Agricultural Experiment Station.

TABLE 1

Morphometry of the *Prionotus stephanophrys* Specimen Taken off the Columbia River

Character	Millimeters	Thousandths of standard length
SL	137	
Body depth	30.4	221
Caudal peduncle depth	8.9	65
Body width at scapular spines	22	160
Snout to end of opercular membrane	49	358
Snout to end of opercular spine	50.2	366
Snout to occiput	30.8	225
Head depth	29	217
Snout width	19	139
Snout length	20	146
Eye	10	73
Bony orbit	12.2	89
Interorbital	9.6	70
Preopercular spine	8.5	62
Upper jaw	20.8	152
Dorsal spines: 1	14.5	106
2	21.8	159
3	24.4	179
4	broken	broken
Anal rays:		
Spine	5	36
Soft rays 1	10.4	76
2	14.2	103
Longest (7th)	20.5	150
Caudal rays:		
Shortest	30.8	225
Longest	36.2	254
Pectoral rays: 1	43.7	319
7	60	437
9	60.5	442
11	47	344
Pelvic fin	37.5	273

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Carl E. Bond, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, and Robert B. Herrmann, Weyerhaeuser Company, Longview, Washington. *Accepted April 1969.*

BOOK REVIEWS

Poisonous Snakes of the World

Granville M. Moore, coordinator and principal editor; U. S. Government Printing Office, Washington, D.C., 1968, viii + 212 p., profusely illustrated in black-and-white, plus 8 color plates. Sold by Superintendent of Documents, U. S. Government Printing Office, Washington, D.C., 20402. $3.25.

Although *Poisonous Snakes of the World* was designed for use by American military forces, who these days find themselves stationed, fighting, and visiting in countries where snakebite poses an additional, and often constant, threat to their safety and well-being, the volume likely will find its greatest acceptance among stay-at-home herpetologists, nature lovers, and book collectors. Those responsible for producing this manual appear to have fulfilled all their stated objectives with room to spare, but they have used such high quality paper in its printing that I seriously doubt the book can withstand exposure to tropical humidity for even a short period. Since poisonous snakes of the humid tropics pose the greatest threat to our military personnel, the coated stock it is printed on limits its effectiveness as "a manual for use by U. S. amphibious forces".

Several introductory chapters are priceless for the information they contain on precautions for avoiding snakebite, recognition of snake venom poisoning, first aid and medical treatment, and recognition of poisonous snakes. The bulk of the text, however, is taken up with descriptive details on various poisonous snakes including their scientific and common names, recognition characters, distribution, behavior, size, and life history. Each such account is concluded with a notation as to the specific antivenin (if such is available) that should be used in case a bite is involved, and most accounts are accompanied by a clear photograph of the species in question.

To facilitate identification, this portion of the text (Chapter VII) has been divided into 10 sections, each representing a "natural" geographic area. All poisonous snakes known to inhabit each area are keyed out and discussed as noted above. Although some of the keys leave much to be desired (e.g., those for the family Elapidae), this shortcoming more often reflects inadequate knowledge of the fauna than ambiguous or poorly selected key characters.

There is a separate chapter on sea snakes, and 12 pages are devoted to a listing of antivenin sources alphabetically by country. Included in this tabular presentation are details regarding the antivenin producer, the name of the product, venoms used in its preparation, and miscellaneous comments regarding use, side effects, etc. Finally, there is a glossary, a list of general references, an index, and eight color plates depicting more than 50 kinds of poisonous snakes. At $3.25, *Poisonous Snakes of the World* is one of the best bargains of the decade, and its purchase could be instrumental in saving a life.—*John E. Fitch.*

Applications de l'Électricité à la Biologie et à l'Aménagement des Pêches Continentales

Symposium under the direction of R. Vibert (Belgrade, 1966); Institut National de la Recherche Agronomique, Versailles, and F.A.O., Rome, 1968; 276 p. 35 F paper. [In French]

Unusual Aquarium Fishes

By Alan Mark Fletcher; J. B. Lippincott Company, Philadelphia, 1968; 143 p., illustrated. $4.50.

Fletcher proposes ". . . to tell aquarists some of the unusual facts about their pets, and to inspire others to take up a fascinating hobby." Experienced aquarists already are familiar with most of the 47 species mentioned. Some little known gems of information are brought forth, however. For example, at one time the betting on Siamese fighting fish, *Betta splendens*, became so intense that entire families were bet into slavery. Another anecdote involves the South American lungfish, *Lepidosiren paradoxa*, which can tolerate a buildup of body wastes as high as 20,000 ppm during estivation.

No book on unusual fishes would be complete without the notorious piranha. Having observed and caught the piranha in its native waters, Fletcher comments, "Surely in all the world there is no more efficient biting animal than the South American piranha." Some of the other interesting creatures mentioned include the sea horse, Amazon leaf fish, mudskipper, and sargassum fish.

Von den Nieuwenhuizen, Wolfsheimer, and the author deserve compliments for the 60 some excellent black-and-white photographs.

Unusual Aquarium Fishes is not particularly suited as a reference source, but does provide an interesting introduction into the fascinating ways of fishes.—*James A. St. Amant.*

Hawaii Goes Fishing

By Jean Scott MacKellar; Charles E. Tuttle Co., Inc., Rutland, Vermont, 1968; 160 p. + photographs. $3.50.

The flyleaf of this little volume states, "There is adventure in these pages for everyone who finds adventure in fishing and especially for the reader who believes that Hawaii possesses a magic all its own." If the statement was inverted to emphasize the magic of Hawaii, and a phrase added to indicate the pages contained a history of Polynesian fishing methods, the reader might have realized the purpose of this book more easily. For, in my opinion, there is far more information concerning the history of fishing techniques in the "enchanted isles" than the average fisherman of today would find relevant to planning a trip to Hawaii.

Mrs. MacKellar prepared this manuscript after World War II while an employee of Honolulu's Board of Public Works. There are many references to the "Territorial Government" and to people who were active in that government prior to Hawaii's statehood in 1959. The Territorial form of government is gone, as well as many of the people who were involved. However, the author chose to ignore this and failed to revise the manuscript since preparation of the preface in 1955.

If one is looking for some light reading and can ignore these shortcomings, this book offers an evening or two of entertaining reading.—*William L. Craig.*

Fish Migration

By F. R. Harden Jones; St. Martin's Press, New York, 1968; viii + 325 p., illustrated. $21.

F. R. Harden Jones states in his introduction: "In this book, an attempt will be made to determine whether or not enough is known about fish migrations to account for the facts, and should the facts themselves prove inadequate, to suggest what further observations and experiments are required." He does the above quite well. The book is a must for anyone planning any fish migration studies.

The author has collected and analyzed information on a large subject and condensed it into a 325 page book. Two introductory chapters cover the biological aspects of migration and the methods of studying fish migrations. There are long chapters on the migrations of various economically important groups of fishes, the studies that went into determining those migrations, the weak points in the studies, and the information needed to prove or disprove various theories, including some which are generally accepted but which Harden Jones feels have not been proved, and others not commonly accepted which he feels have never been disproved. Included are chapters on: "Salmon and Trout", "The Eel", "The Herring" (58 pages), "The Cod", and "The Plaice". Conspicuous by their absence were the tunas and the mackerels. (The author explains that the tuna literature is so large that it would have taken another two or three years of study to prepare him to write about that group.)

After the discussion of the fishes themselves, there is a change in the basic organization of the book. There are chapters on: "The Reactions of Fish to Stimuli", "Movement Without Reference to Local Landmarks", and "Homing and the Use of Local Landmarks". Earlier in the book I had felt exasperated by important omissions from the chapter on salmon and trout. Much of the "omitted" material turned up in the three chapters just listed.

The "References/Author Index" includes an awesome 900 titles but a quick reading of the list did reveal the absence of a moderate number of works I would regard as being at least as important as the bulk of the references included. The subject is indeed a large one.

There is a subject index and a geographical index.—*Donald H. Fry, Jr.*

The Farming of Fish

By C. F. Hickling; Pergamon Press, Inc., New York, 1968; vii + 88 p. $3.50 cloth, $2.00 paper.

This little book contains much basic scientific information on physical and chemical characteristics of water managed for fish production. It is written in nontechnical style and is composed with easily understood words. The 12 chapters cover these subjects: "Introduction", "A Historical Digression", "The Primary Source of Material and Energy in a Fish Pond", "The Water Supply", "The Quality of the Water", "The Basis of Fish Farming", "The Pond Soil", "The Biology of a Fish Pond", "Fish Farming", "The Stocking of Fish Ponds", "Fish Farming in the Sea", and "Why Not More Fish Farming". Treatment is generalized throughout.

I hoped to find some practical information on building ponds, laying out waterworks, and specific information on feeding fish. These items were not found. I also failed to find management information on stocking rates and methods of harvesting and processing fish produced at fish farms. Obviously, some things could not be included in such a small book, and it is to the author's credit that he found space for as much detail as the book contains.—*J. H. Ryan.*

Reservoir Fishery Resources Symposium

Presented by the Reservoir Committee of the Southern Division, American Fisheries Society; Southern Division, A.F.S., 1968; viii + 569 p., illustrated. Orders, accompanied by remittance payable to the Southern Division, A.F.S., should be sent to the Secretary, Southern Division, A.F.S., through Dr. Robert F. Hutton, Executive Secretary, American Fisheries Society, Suite 1040, Washington Building, 15th Street and New York Avenue, N.W., Washington, D. C. 20005. $10 paper.

This publication is a collection of papers given at the symposium April 5–7, 1967. Following the welcoming address, there are four papers representing viewpoints of the U. S. Fish and Wildlife Service, the U. S. Army Corps of Engineers, the U. S. Bureau of Reclamation, and the states. The next 34 papers cover a plethora of topics relating to reservoirs, their management, productivity, water quality, fishery resources, and recreational aspects. A summary completes the book.

There is a wealth of information in this publication. I can't conceive of a freshwater biologist who would not be interested in some, if not all, of the papers presented. The Reservoir Committee did an outstanding job of putting together a well-rounded program, and in obtaining experts in the various disciplines to prepare the papers. New insights into reservoir ecology which question or contradict some of our long-held beliefs are presented. They should spur additional research to better manage our reservoirs.—*Leonard Fisk.*

Systematics, Distribution, and Abundance of the Epiplanktonic Squid (Cephalopoda, Decapoda) Larvae of the California Current, April, 1954–March, 1957.

By Takashi Okutani and John A. McGowan; University of California Press, Berkeley and Los Angeles, 1969; v + 90 p., illustrated. $3 paper.

Any scientist who has tried to research cephalopods knows painfully well that there is a comparatively large vacant space in the scientific literature concerning the taxonomy and biology of the squids. Okutani and McGowan's paper is an excellent step toward filling the aforementioned void.

The paper is composed of two sections. The first deals with the systematics and descriptions of the larval stages of 14 species of decapod cephalopods. Two squids, *Liguriella* sp. and *Octopodoteuthopsis* sp., were previously undescribed. Each species covered in the text is accompanied by a thorough written description and excellent drawings. The species are so well described that this paper may be used as a key, although it is not intended for that purpose.

The second portion of the paper is concerned with distribution and abundance and includes the distribution of the adult stages. Five species, *Ctenopteryx sicula*, *Chiroteuthis veranyi*, *Pyrgopsis pacificus*, *Teuthowenia megalops*, and *Helicocranchia pfefferi*, were previously not known from the California Current System. Three species, *Loligo opalescens*, *Meleagroteuthis hoteropsis*, and *Abraliopsis felis*, are endemic to the California Current. Two species, *Pterygioteuthis giardi* and *Onychoteuthis banksii*, are nearly cosmopolitan, while one species, *Gonatus fabricii*, is found only in the Northern Hemisphere. The final squid discussed is the Rhynchoteuthion larva. This larval form is not linked to an adult species and no distribution is given, nor is any distribution given for the two undescribed species, other than that they do occur in the California Current.

The material on abundance of larvae is sparse at best, due to the difficulty in sampling pelagic species. However, the abundance of the more common larvae is cyclical in nature and suggests seasonal spawning.

The paper is well written and quite readable. The text is followed by a list of 109 references on octopod and decapod cephalopods. The references would be an excellent research focal point.

I can find no fault with this paper, other than the fact that there are many adult species known from the California Current whose larval forms were not covered. This can only be remedied by time and effort spent in collecting and research. I trust that the authors will keep up the good work.—*Jerome D. Spratt.*

The Fertile Sea

By A. P. Orr and S. M. Marshall; Fishing News (Books) Ltd., London, 1969; 131 p., illustrated. £2 15s. 0d.

Dr. A. P. Orr delivered the Buckland lectures in 1957. Unfortunately, he died before the manuscript was completed. Dr. S. M. Marshall, a colleague of his at Millport, undertook the final preparation of the book.

The productivity of the oceans as an eventual food source for man is the central theme of the book. Such a narrow outlook certainly detracts from an appreciation of the varied forms of life found in the oceans, many of which are of little importance either as primary or secondary food sources. But this only points out again that mankind's immediate concern is with feeding an ever-increasing world population.

The book is really more of an outline of the many factors affecting the productivity of the oceans from the essential nutrients up the food chain to the shellfishes and fishes. The authors, in covering such an extensive subject in 130 pages, barely touch on the many facets involved. As a result, people working in biological oceanography will find few things in the work that will be new to them. The book, however, is written so that those with little biological background can read it and gain some understanding of the complex web of life whose end products are becoming an increasingly important food source. Anyone wishing to gain a cursory knowledge of the oceans' productivity would do well to read the seven chapters.—*John J. Geibel.*

More Free-for-the-Eating Wild Foods

By Bradford Angier; Stockpole Books, Harrisburg, Pa., 1969; 192 p., illustrated. $4.95.

As indicated by the title, this book is a sequel to an earlier publication by the author on edible wild plants. The index, labeled "Directory of Wild Plants", reveals the large number of plants which are discussed in the text. Readers in all parts of the country will find that some of the wild foods listed are available within a short distance of their homes—perhaps as close as the vacant lot across the street.

Only a few decades ago, many of the plants described in the book were commonly used and enjoyed by people who relied on the countryside rather than a supermarket for much of their food. It is not the author's purpose to discourage shopping by reviving an interest in Nature's free-for-the-taking food supply. Rather, he wishes to share the pleasure he receives from his hobby of preparing tasty dishes from wild foods. The detailed recipes are easy to follow and a garnish of historical information makes the description of some of the plants more than just a botany lesson. (Did you know that the prairie turnip helped the Sioux defeat Custer?) This book will appeal to those with a keen interest in the outdoors and an appetite for unique food.—*George H. Warner.*

History of the Sierra Nevada

By Francis P. Farquhar; University of California Press, Berkeley and Los Angeles, 1969; xiv + 262 p., illustrated. $2.65 paper.

This is the fourth printing and first paperback edition of Francis Farquhar's authoritative and at the same time charming and thoroughly readable account of the Sierra Nevada. A full review was published in *California Fish and Game*, 52 (3) : 224, 1966.—*Leo Shapovalov.*

Sportsman's Guide to Game Fish

By Byron Dalrymple; The World Publishing Company, New York and Cleveland, 1968; xvi + 480 p., illustrated. $6.95.

Although a nonprofessional, the author has done a very creditable job. The book isn't quite as informative as stated on the front cover flap (". . . all the necessary facts on every game fish in the United States—") but enough material is presented in a flowing, readable style to make it a worthwhile purchase for any serious fisherman. An account is given for each species or group of related species. Tackle, fishing methods, and life histories comprise the main substance of these accounts. The book has two parts, one on freshwater and the other on saltwater game fish. Sturgeon, salmon, and American shad are described in the freshwater section and striped bass are included in the saltwater section.

As might be expected, inconsistencies and technical errors detract from the book's reliability. The following are a few examples: (i) all sturgeon are given one scientific name, (ii) paddlefish are included in the catfish group (however, their difference from this group is acknowledged), and (iii) the golden trout ". . . in its celebrated original form and color exists only at western altitudes of 9,000 to 12,000 feet." Some statements, such as the following, are unfounded: "The black bass is our top game fish, with the various trouts second."

The color plates are rather crude and substitutes should have been provided.

In spite of these shortcomings, the book is still superior to the usual sportsman's publication.—*John W. Emig.*

Mulberry Trout

By Ogden Bigelow; Charles E. Tuttle Co., Inc., Rutland, Vermont, 1969; 213 p., illustrated. $5.

This is the first book for the author, a retired banker and a weekend angler. Athough an ardent fly-fisherman himself, it was refreshing that he did not dwell on the superiority of this "pure" form of art, and did not belittle those who might have other preferences.

Essentially, *Mulberry Trout* is a collection of stories about some of the author's experiences. These occur in various parts of the U. S., Canada, England, and Chile. The fact that Mr. Bigelow is the goat in many instances adds to the delight of these stories.

The print is large and easy to read, and the illustrations are well done. This book is good for several evenings of light and entertaining reading.—*Leonard Fisk.*

The Tule Elk: Its History, Behavior, and Ecology

By Dale R. McCullough; University of California Press, Berkeley and Los Angeles, 1969; vii + 209 p., illustrated. $6.50 paper.

This publication provides the most authoritative information on the history, behavior, and ecology of the Tule elk. It is most timely, since this subspecies is listed as a rare species by both the report on Rare and Endangered Fish and Wildlife of the United States, and the International Union for Conservation of Nature and Natural Resources.

The management of the Owens Valley herd, which includes closely regulated hunting from time to time, has been the subject of intense controversy. The author conducted a 2-year full-time field study in the Owens Valley and conducted limited studies of the Cache Creek and Tupman herds. This work makes a significant contribution to the knowledge of Tule elk and brings out several points that should be considered by all zoologists in conducting life history studies on herbivores.

Dr. McCullough provides substantiated evidence that elk and red deer are a single species and that the Tule elk, as are the other forms of elk, are a subspecies. The history of Tule elk, including their decline and recovery and the various transplants, is well covered. The major portion of this publication is devoted to elk in the Owens Valley, where the largest group of Tule elk is located. Life history, behavior, range relationships, and population dynamics are given a thoroughly professional treatment.

An extremely valuable section is the one on the management and preservation of Tule elk. This section should be of particular interest to all who are interested in Tule elk.

In my opinion this publication reports on one of the finest wildlife studies to be produced by the University of California in recent years.—*Wallace G. Macgregor.*

The Natural History and Behavior of the California Sea Lion

By Richard S. Peterson and George A. Bartholomew; Special Publication No. 1, The American Society of Mammalogists, Secretary-Treasurer Dr. Bryan P. Glass, Department of Zoology, Oklahoma State University, Stillwater, Oklahoma 74074, 1967; xi + 79 p., illustrated. $3.50.

In recent years with the rapid increase of California sea lions, *Zalophus californianus*, along the California coast, there has been a corresponding increase in interest and concern over these animals. However, until recently little was known of these animals. Published accounts were fragmentary and were often concerned with isolated subpopulations.

The Natural History and Behavior of the California Sea Lion is the first detailed account of the natural history and behavior of *Zalophus* from the California coast. The book presents results of studies conducted on San Nicolas Island, California, during the spring and summer of 1965.

Emphasis is placed on individual mannerisms and social behavior of the California sea lion. Behavioral patterns are classified as nonreproductive behavior, reproductive behavior, mother-young relations, and ontogeny of pup behavior. These subjects are well covered and the text is well supplied with excellent photographs depicting the various behavioral aspects of *Zalophus*.

Other topics covered to a lesser degree are general biology and population dynamics. This is unfortunate, because of the ever-present controversy concerning the effects of California sea lions and other pinnipeds on the commercial and sport fisheries along our coast. This controversy points out the need for more studies on the biology of *Zalophus*, including food habits, as well as studies on the population size and distribution along our coast.

This publication is a valuable contribution to the understanding of the natural history and behavior of the California sea lion and hopefully will give impetus to further studies into the relationship of this important and interesting marine mammal to man and the marine environment.—*Melvyn W. Odemar.*

Methods for Assessment of Fish Production in Fresh Waters

Edited by W. E. Ricker; Blockwell Scientific Publications, Oxford and Edinburgh, 1968; 328 p. (IBP Handbook No. 3). Available in U. S. from F. A. Davis Co., 1914 Cherry St., Philadelphia, Pa. 19103. $6.50 paper.

The International Biological Programme, a worldwide plan of research concerned with "the biological basis for productivity and human welfare", has sponsored a series of handbooks to be used by biologists around the world who are participating in the Programme. This volume is one of four concerned with methods of studying productivity in fresh waters. The remaining volumes, which are in preparation, will consider primary and secondary productivity and chemical methods.

Each of the 13 chapters is authored by internationally prominent biologists expert in such subjects as: capture, sampling, and examination of fishes; fish identification; tagging and marking; age and growth; population dynamics; causes of mortality; and others.

The detail of the several subjects varies. The chapter on capture, sampling, and examination of fishes by Karl F. Lagler is excellent. His description of gear and its use is, alone, worth the price of the book. Generally, the subject matter is meant to complement other works, particularly those in *The Biological Basis of Freshwater Fish Production*, a presentation of papers given at the 1966 IBP symposium. One of the tasks at the symposium was to initiate this series of handbooks.

The title of this handbook could be amended somewhat, since the scope is limited to *wild* fish production. Fish culture and management are not specifically covered, although one need not tax his imagination to discover the application of many of the techniques.

This book will make a valuable suppplement to a fishery biologist's library. It is not for popular reading.—*Larry K. Puckett.*

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Notice is hereby given that the Fish and Game Commission shall meet on October 3, 1969, at 9 a.m. in Room 1138, New State Building, 107 So. Broadway, Los Angeles, California, to receive recommendations from its own officers and employees, from the Department of Fish and Game and other public agencies, from organizations of private citizens, and from any interested groups as to what, if any, regulations should be made relating to fish, amphibia, and reptiles, or any species or subspecies thereof.

Notice is hereby given that the Fish and Game Commission shall meet on October 31, 1969, at 9 a.m. in Room B109, State Building, 1350 Front Street, San Diego, California, for public discussion of and presentation of objections to the proposals presented to the Commission on October 3, 1969, and after considering such discussion and objections the Commission, at this meeting, shall announce the regulations which it proposes to make relating to fish, amphibia, and reptiles.

Notice is hereby given that the Fish and Game Commission shall meet on December 5, 1969, at 9 a.m. in the Main Auditorium, Resources Building, 1416 Ninth Street, Sacramento, California, to hear and consider any objections to its determinations or proposed orders in relation to fish, amphibia, and reptiles, or any species or subspecies thereof for the 1970 sport fishing seasons, such determinations and orders resulting from the hearings held on October 3, 1969, and October 31, 1969.

Fish and Game Commission
Leslie F. Edgerton
Executive Secretary

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